

# (12) UK Patent Application (19) GB (11) 2 399 120 (13) A

(43) Date of A Publication 08.09.2004

(21) Application No: 0411894.9  
(22) Date of Filing: 17.09.2001  
Date Lodged: 27.05.2004  
(30) Priority Data:  
(31) 60233638 (32) 18.09.2000 (33) US  
(62) Divided from Application No  
0303220.8 under Section 15(4) of the Patents Act 1977

(51) INT CL<sup>7</sup>:  
E21B 43/10 33/14

(52) UK CL (Edition W):  
E1F FJT FLA

(56) Documents Cited:  
US 6085838 A

(58) Field of Search:  
Other: U.S. 166/277,382,177.4,206,207,242.2

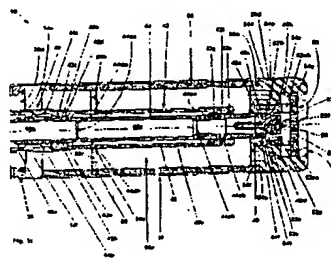
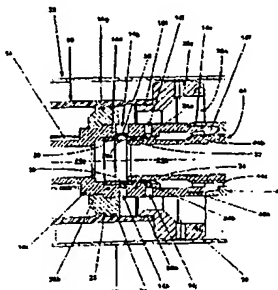
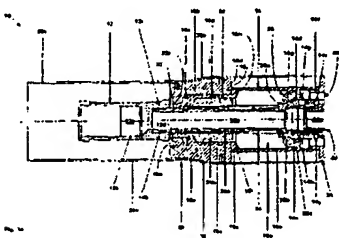
(71) Applicant(s):  
Shell Internationale Research Maatschappij B.V.  
(Incorporated in the Netherlands)  
Department IP/43 Carel Van Bylandtlaan  
30, 2596 HR The Hague, Netherlands

(72) Inventor(s):  
David Paul Brisco  
Edwin Arnold Zwald Jr  
Chan Daigle  
Gregory M Noel  
William J Dean

(continued on next page)

(54) Abstract Title: **Forming a wellbore casing**

(57) An apparatus for forming a wellbore casing within a borehole comprises a first tubular support member 12 defining a first fluid passage 12a and a radial passage 14g having a rupture disc 36 fluidically coupled to the first fluid passage 12a; an annular expansion cone 18 coupled to the first tubular support member 12a; an expandable tubular member 20 movably coupled to the expansion cone 18; a shoe 54 defining a second fluid passage 54a coupled to the expandable tubular member 20; an annular valve member 44 defining a third fluid passage 44a fluidically coupled to the first 12a and second 54a fluid passages having first and second throat passages 44aa,44ab, defining second and third radial passages 44da,db,ea and eb fluidically coupled to the third fluid passage 44a, coupled to the shoe 54, and movably coupled to the first tubular support member 12; and an annular sleeve 42 releasably coupled to the first tubular support member 12 and movably coupled to the annular valve member 44 for controllably fluidically coupling the second and third radial passages 44da,db,ea and eb; and wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.



GB 2 399 120 A

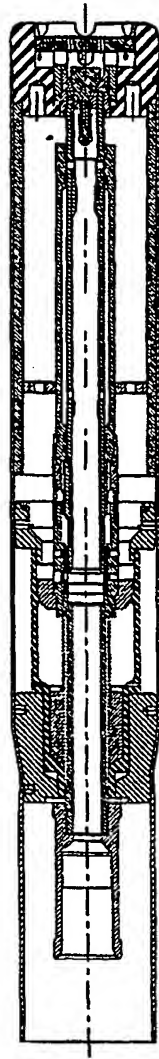
**GB 2399120 A continuation**

**(72) cont**

**Andrei Gregory Filippov  
Ronald D Nida  
Robert Lance Cook  
Lev Ring  
Kevin K Wadell  
William Rusty Stephenson  
Rune T Gusevik**

**(74) Agent and/or Address for Service:**

**Haseltine Lake & Co  
Redcliff Quay, 120 Redcliff Street,  
BRISTOL, BS1 6HU, United Kingdom**



10 →

Fig. 1

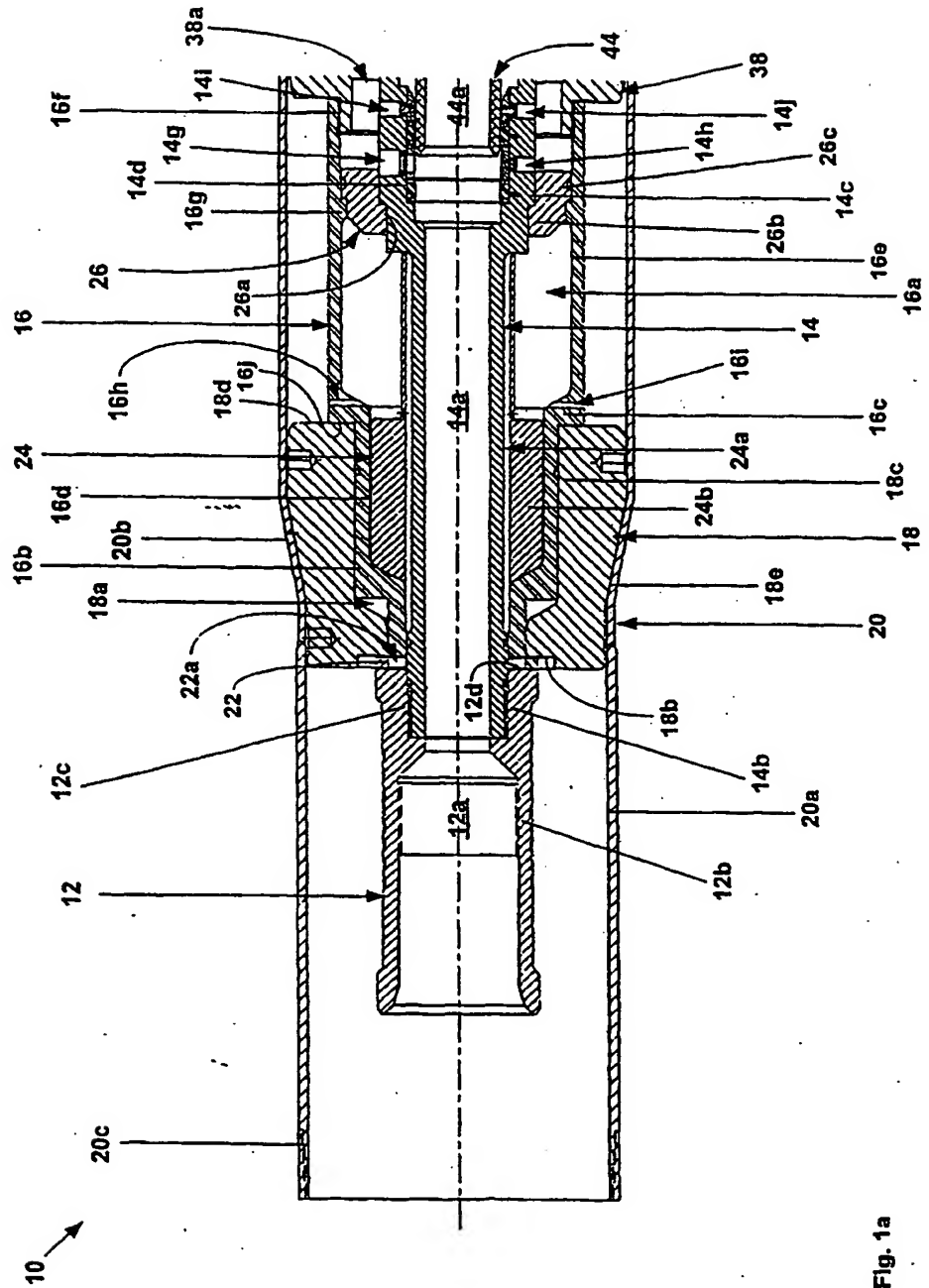


Fig. 1a



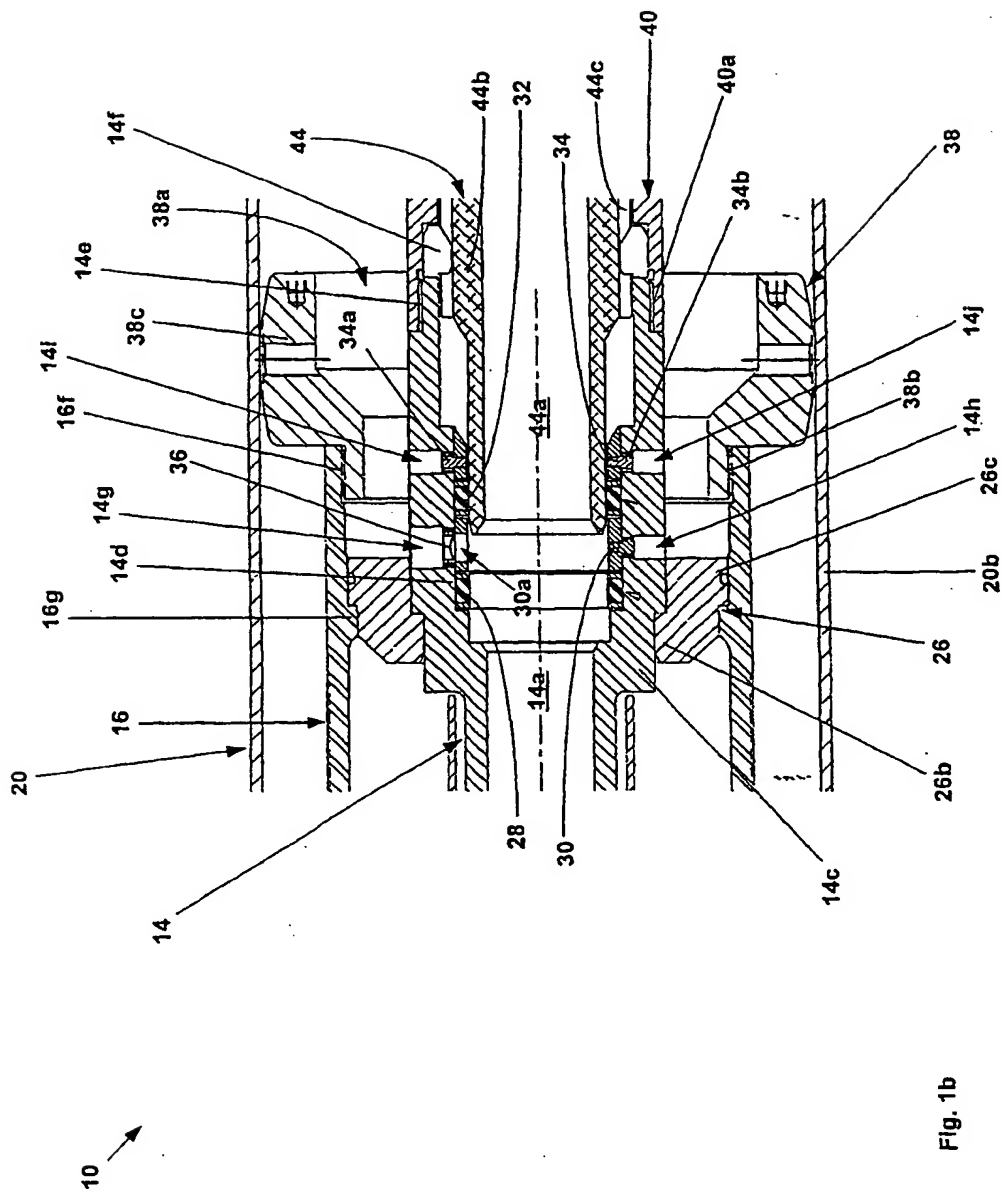


Fig. 1b

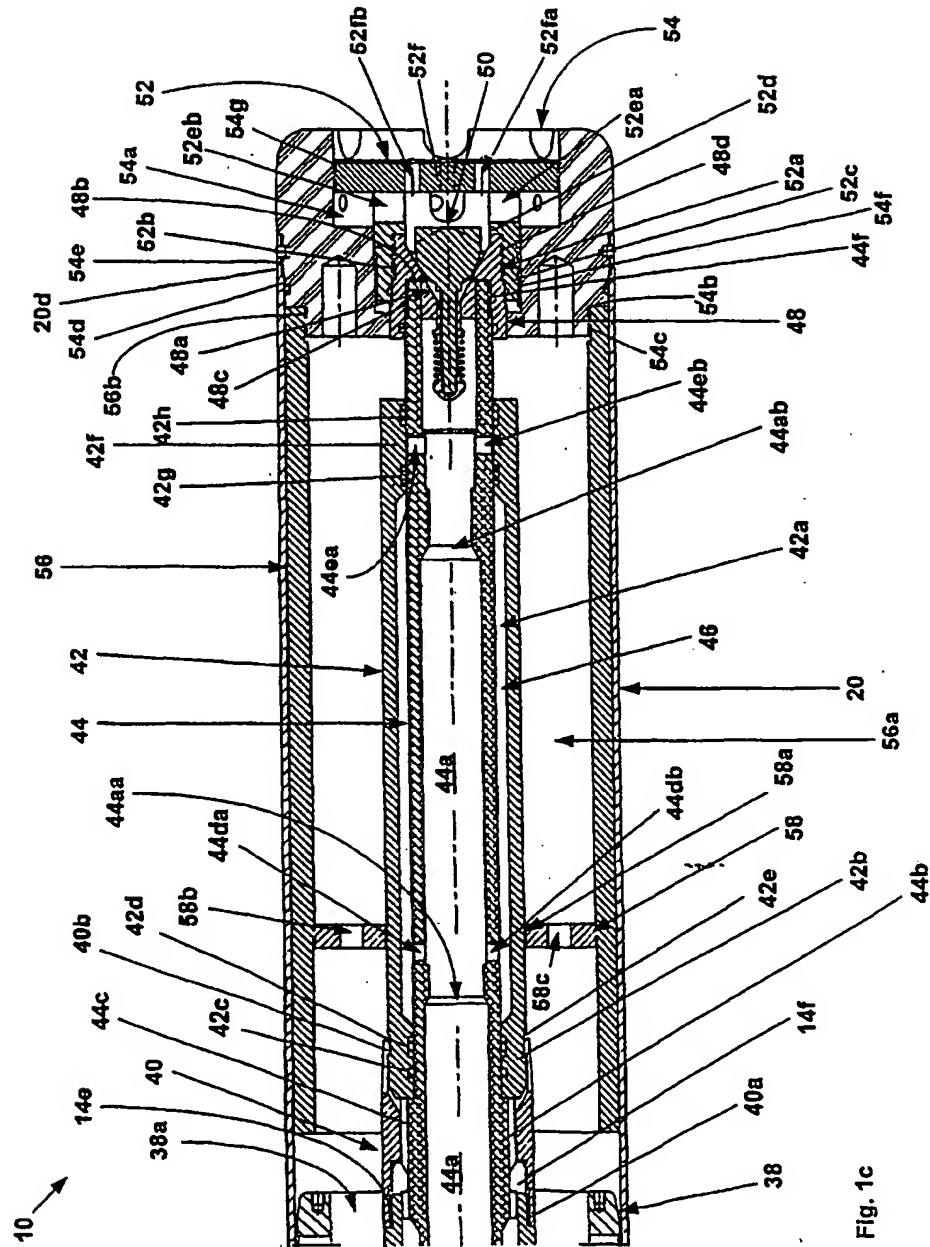


Fig. 1c

200

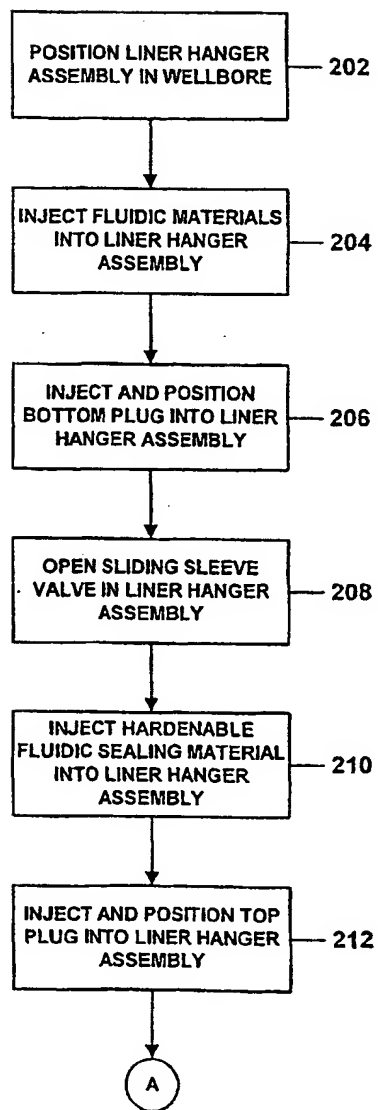


Fig. 2a

200

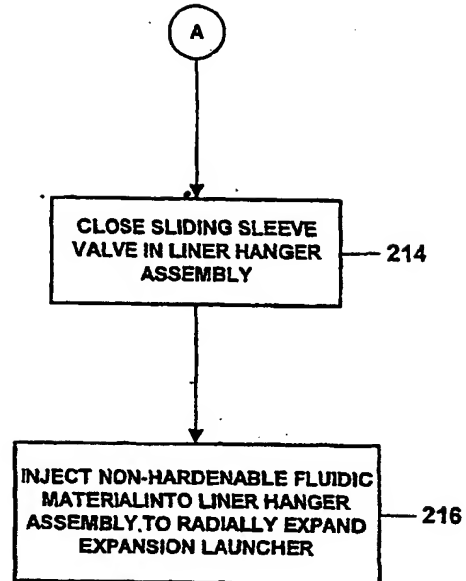


Fig. 2b

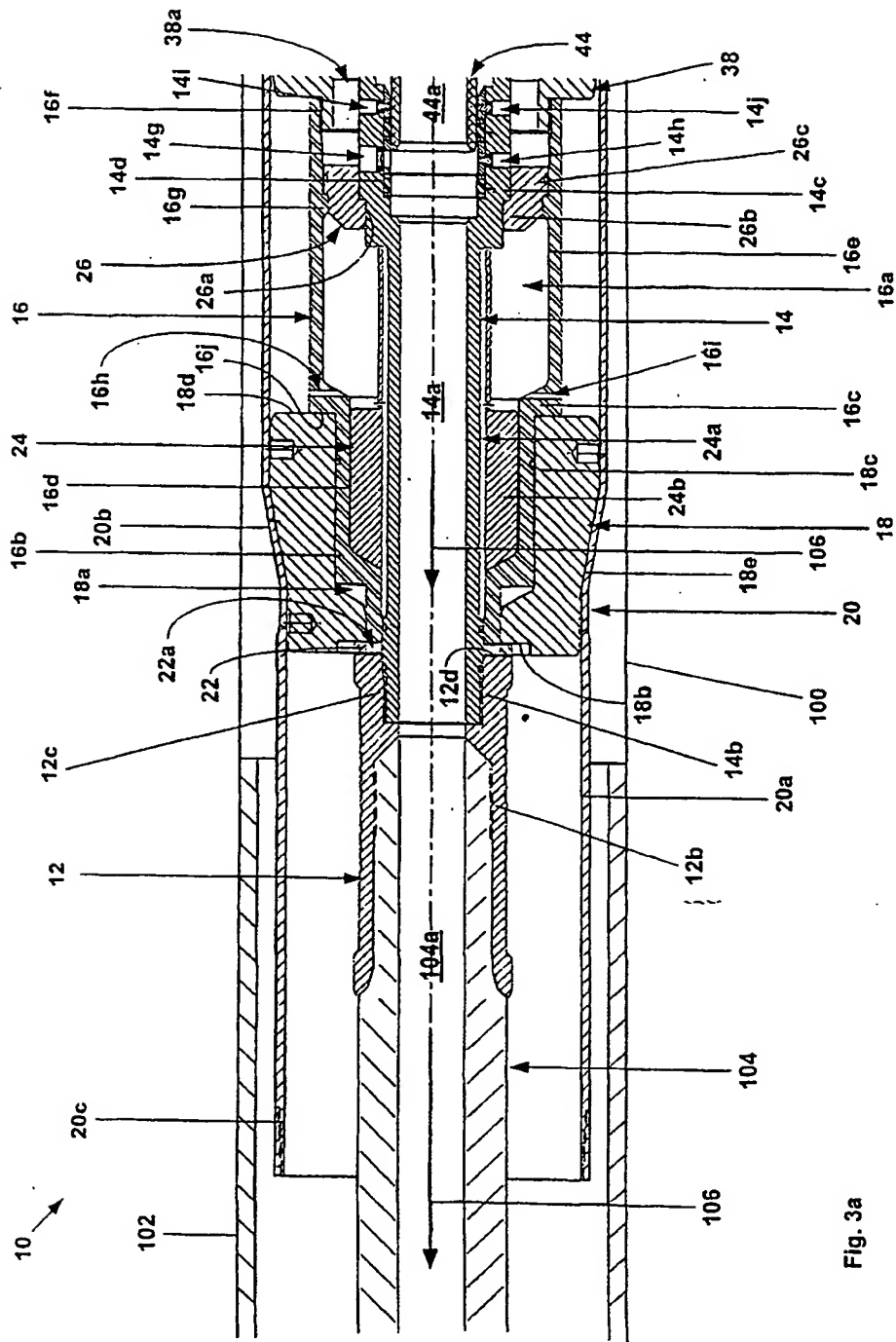


Fig. 3a

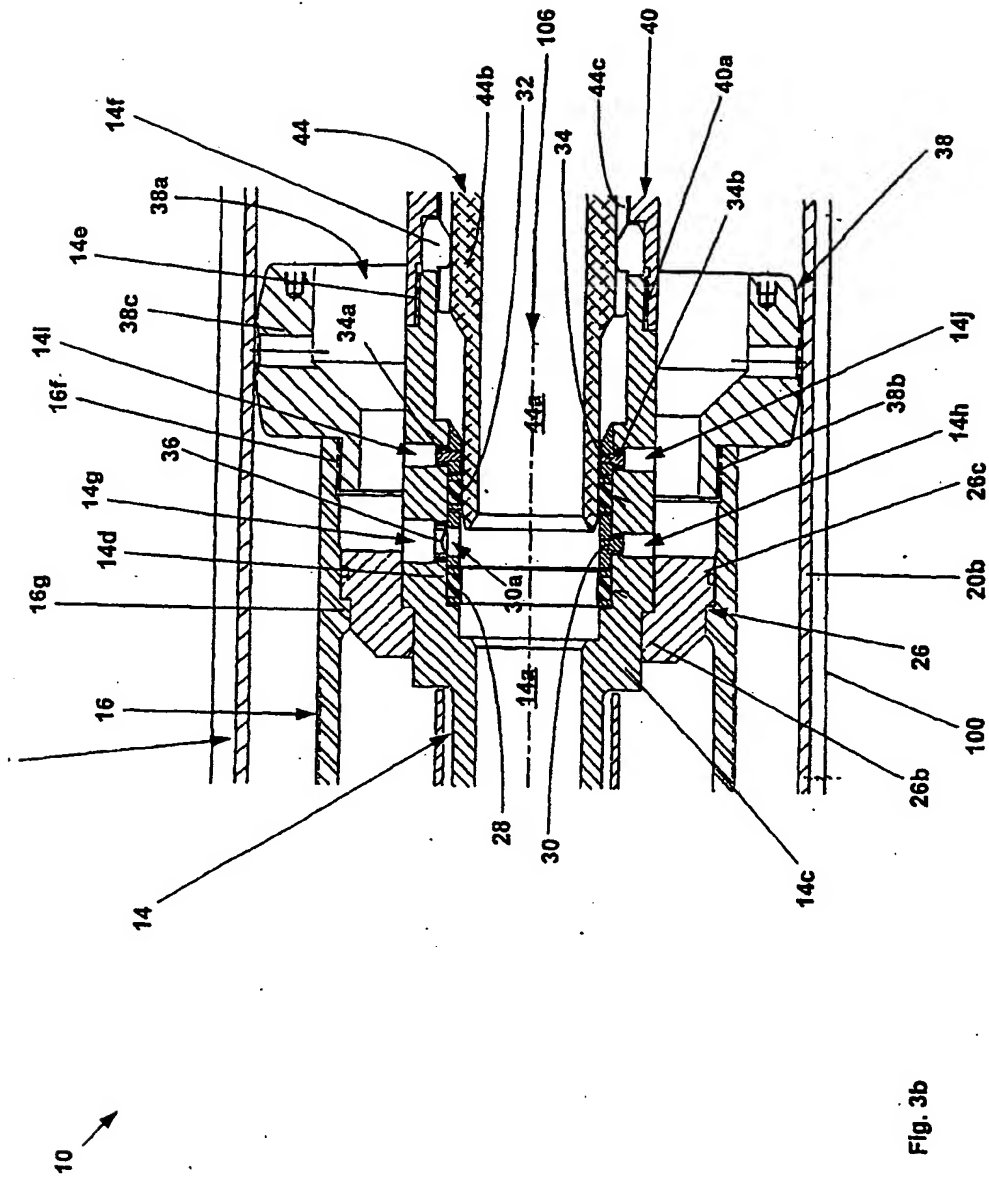


Fig. 3b

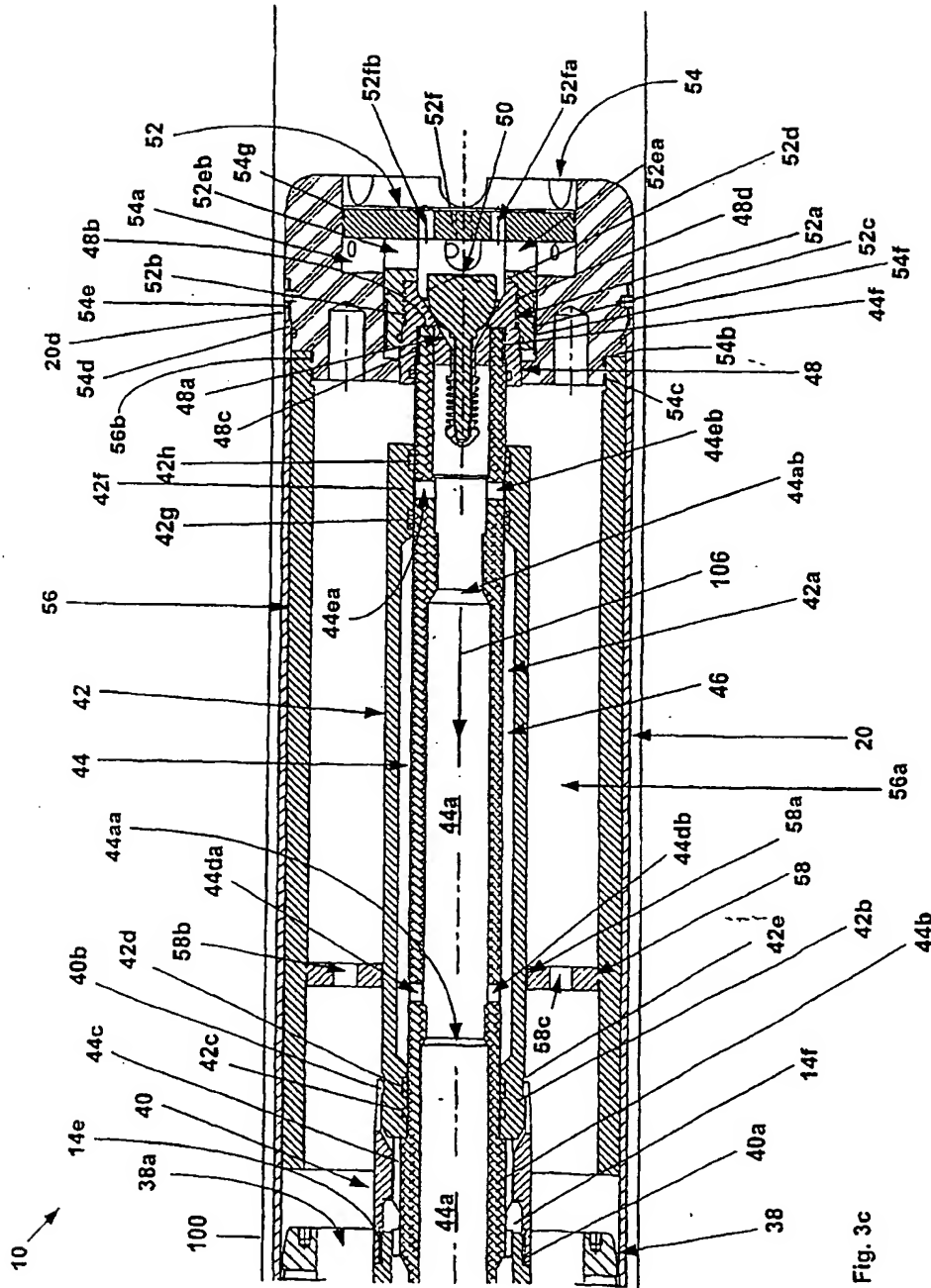


Fig. 3c

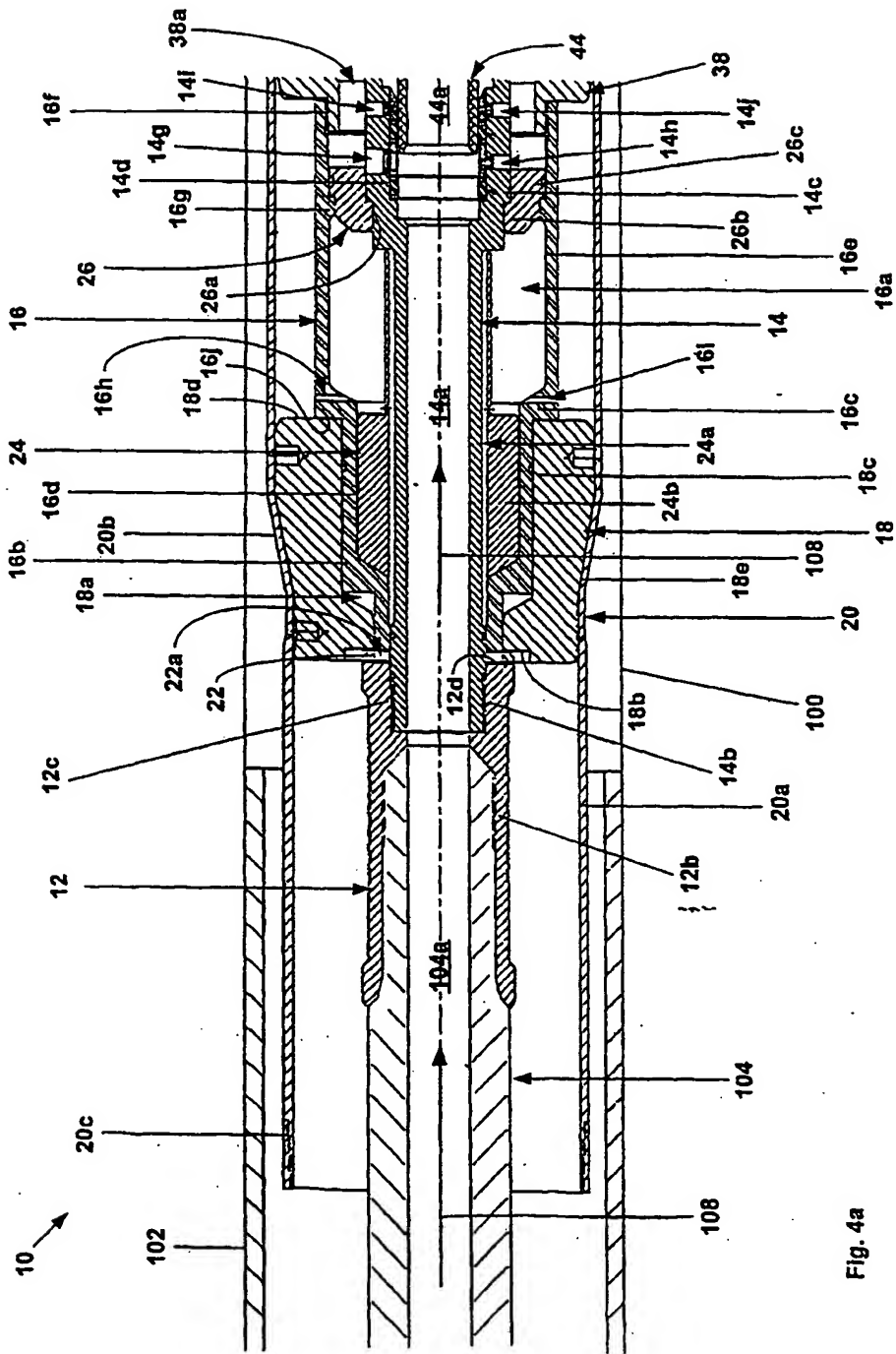
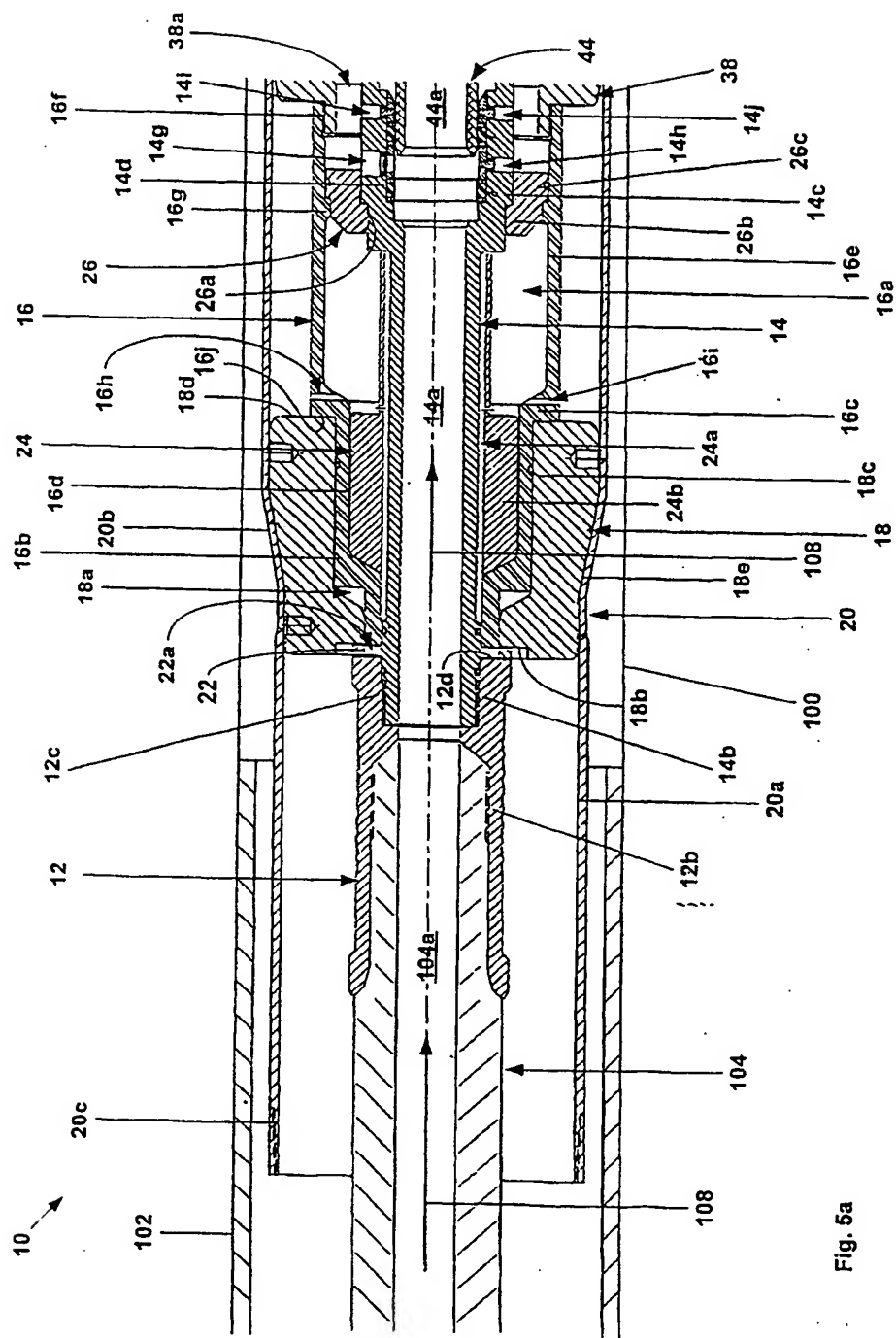


Fig. 4a









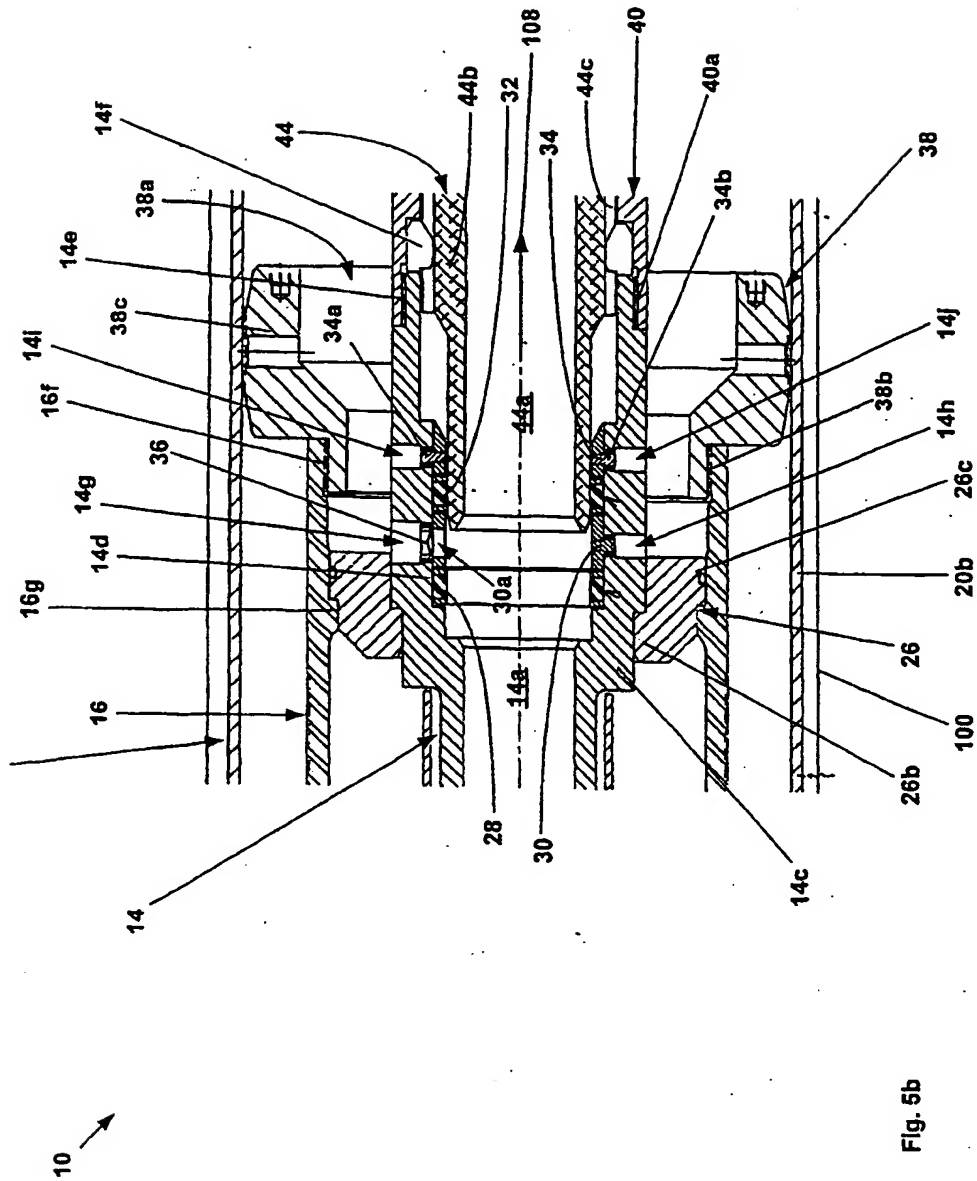


Fig. 5b

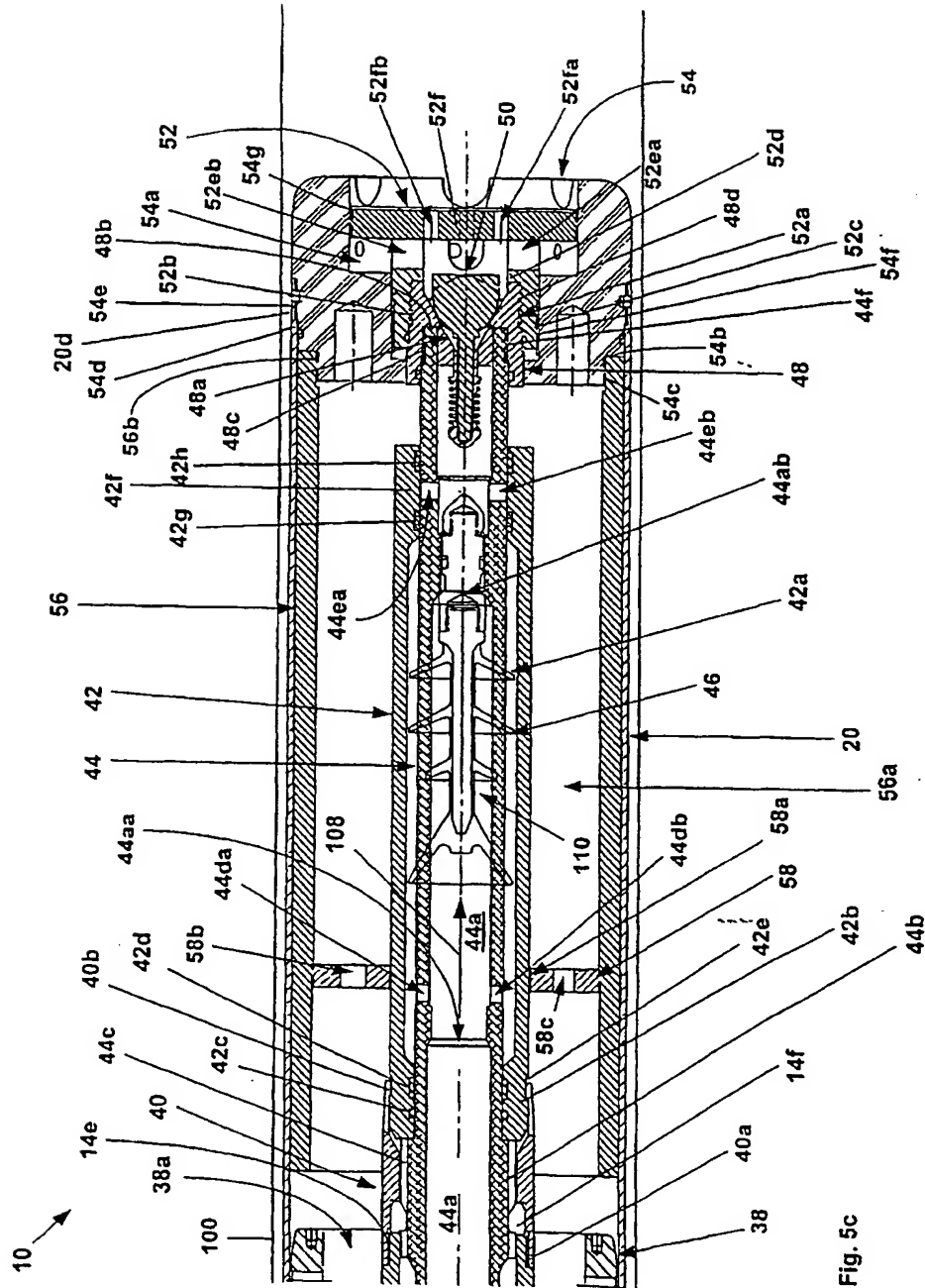


Fig. 5c



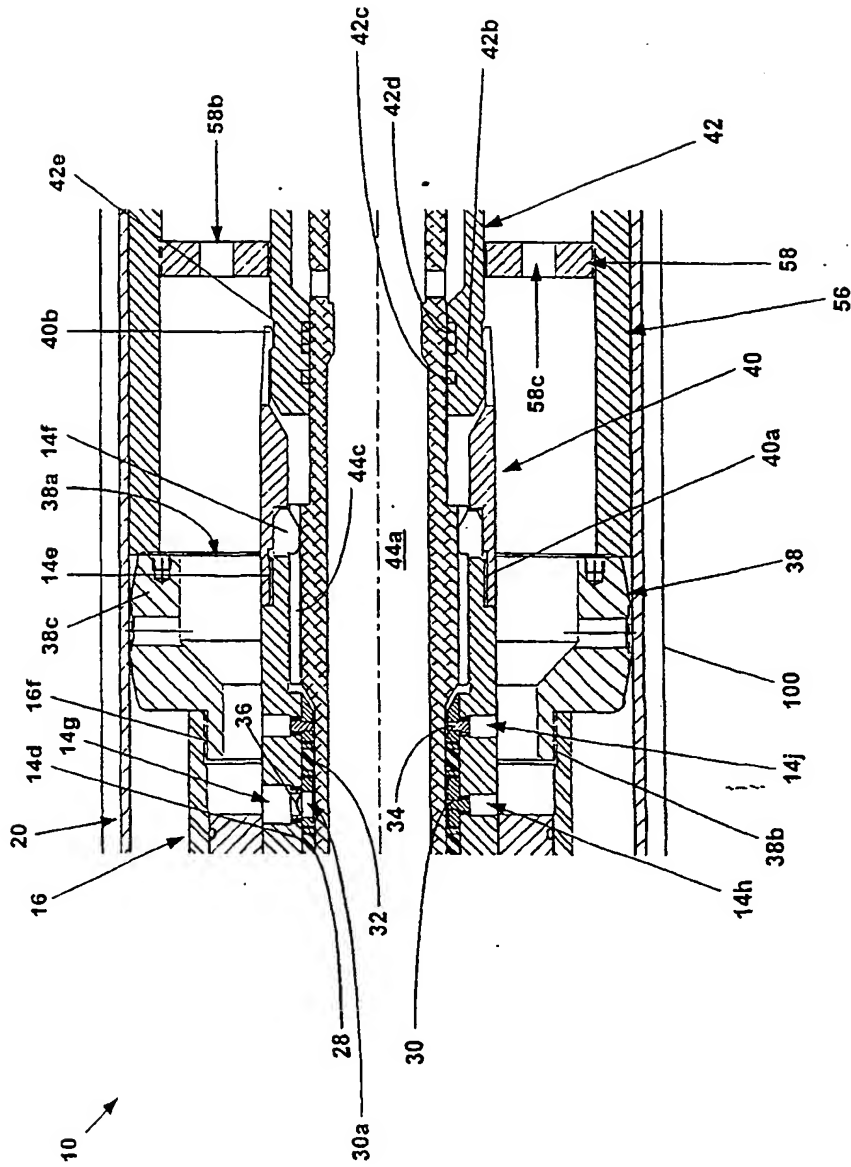


Fig. 6b

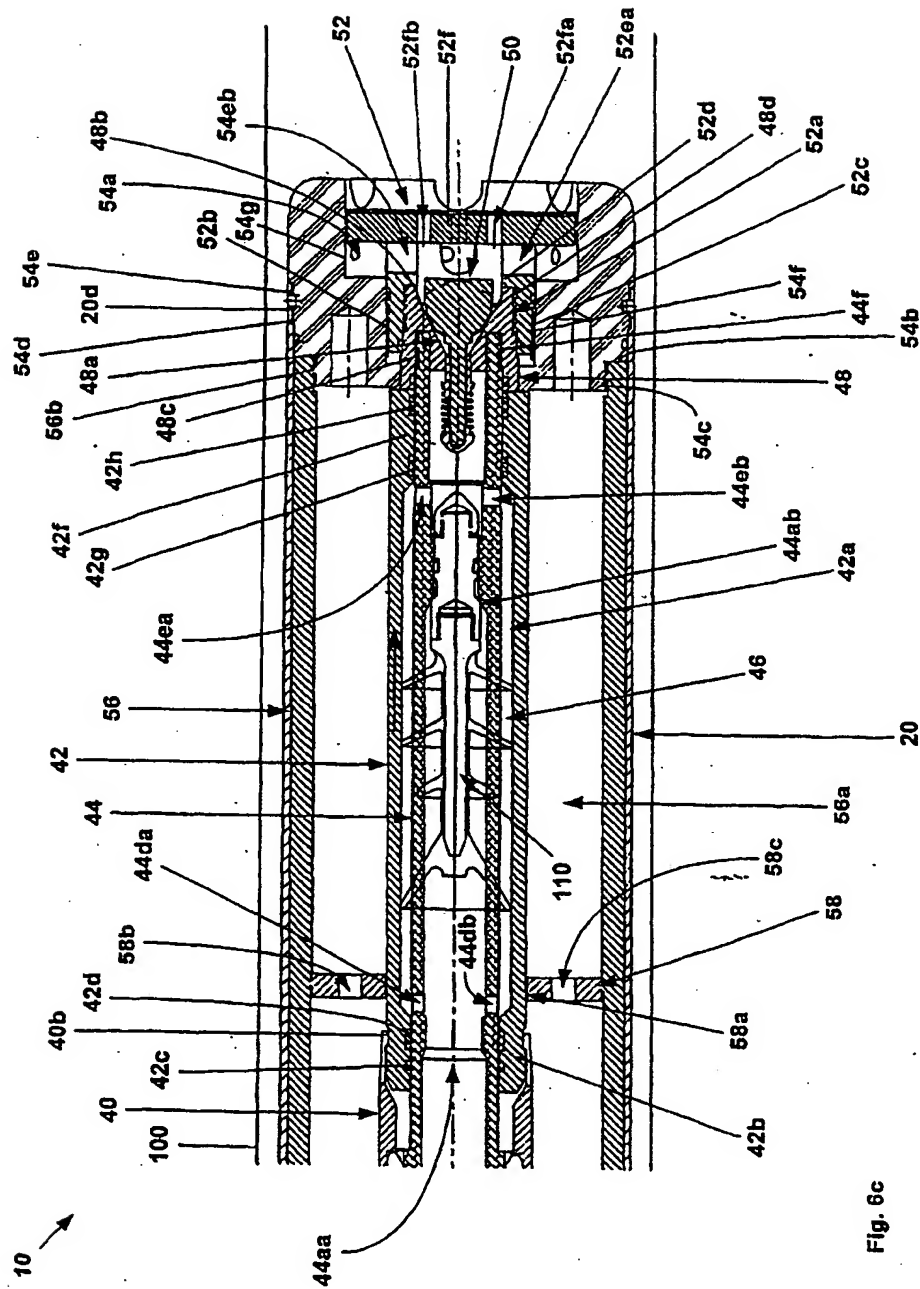


Fig. 6c



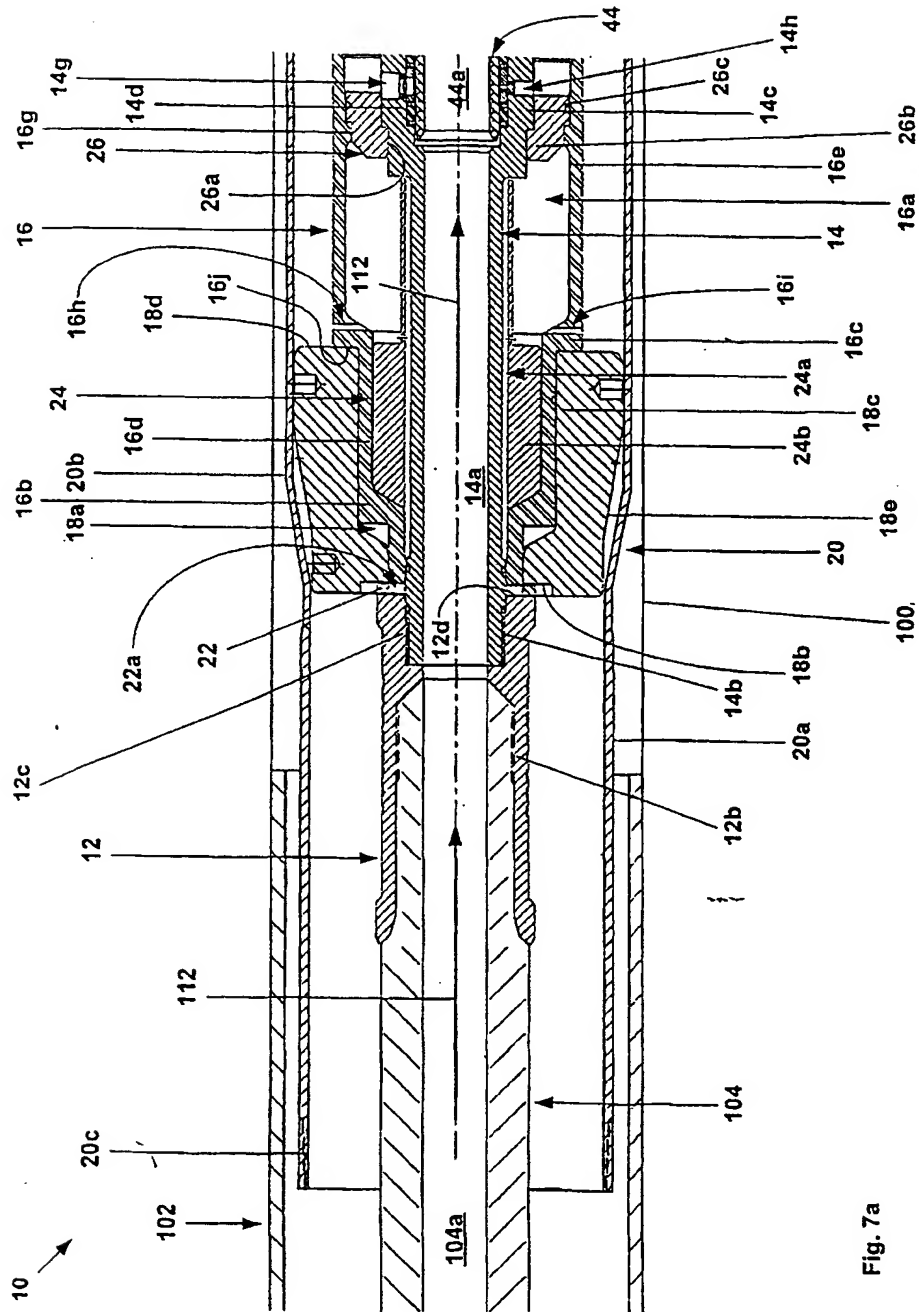
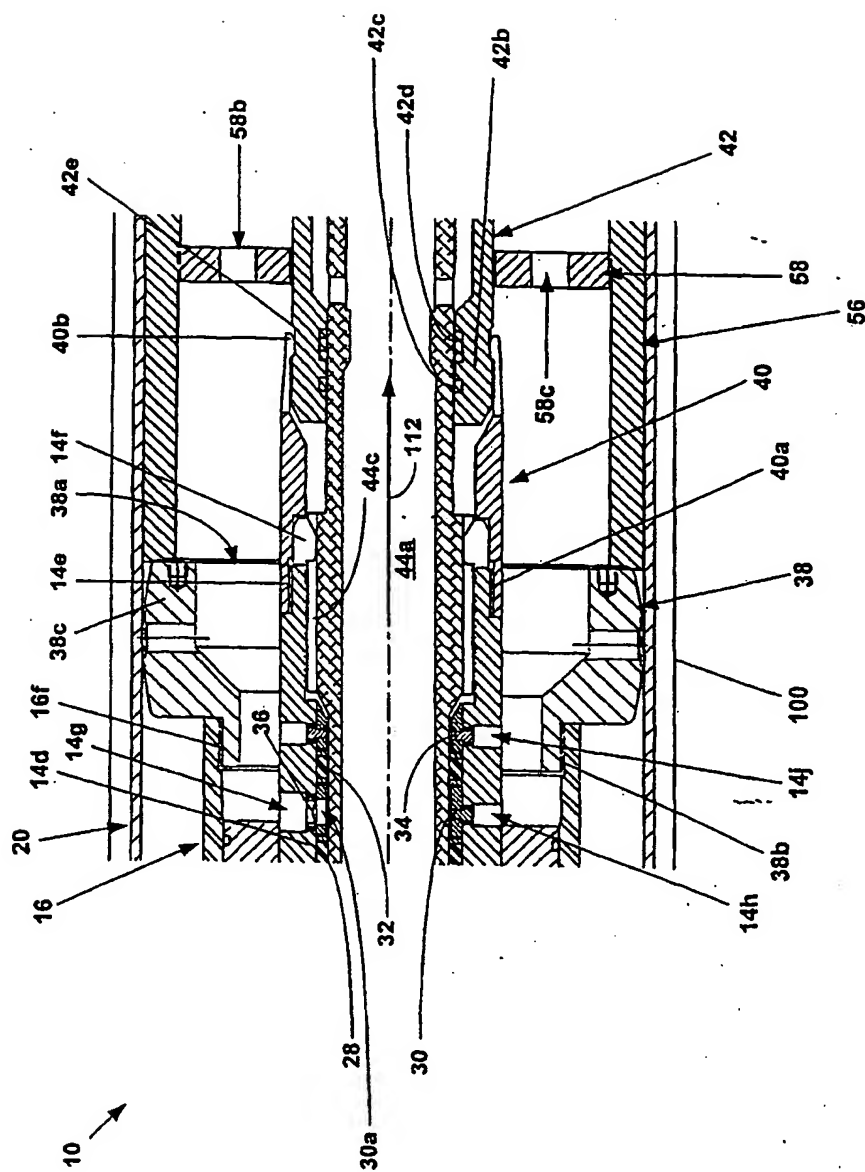


Fig. 7a



**Fig. 7b**

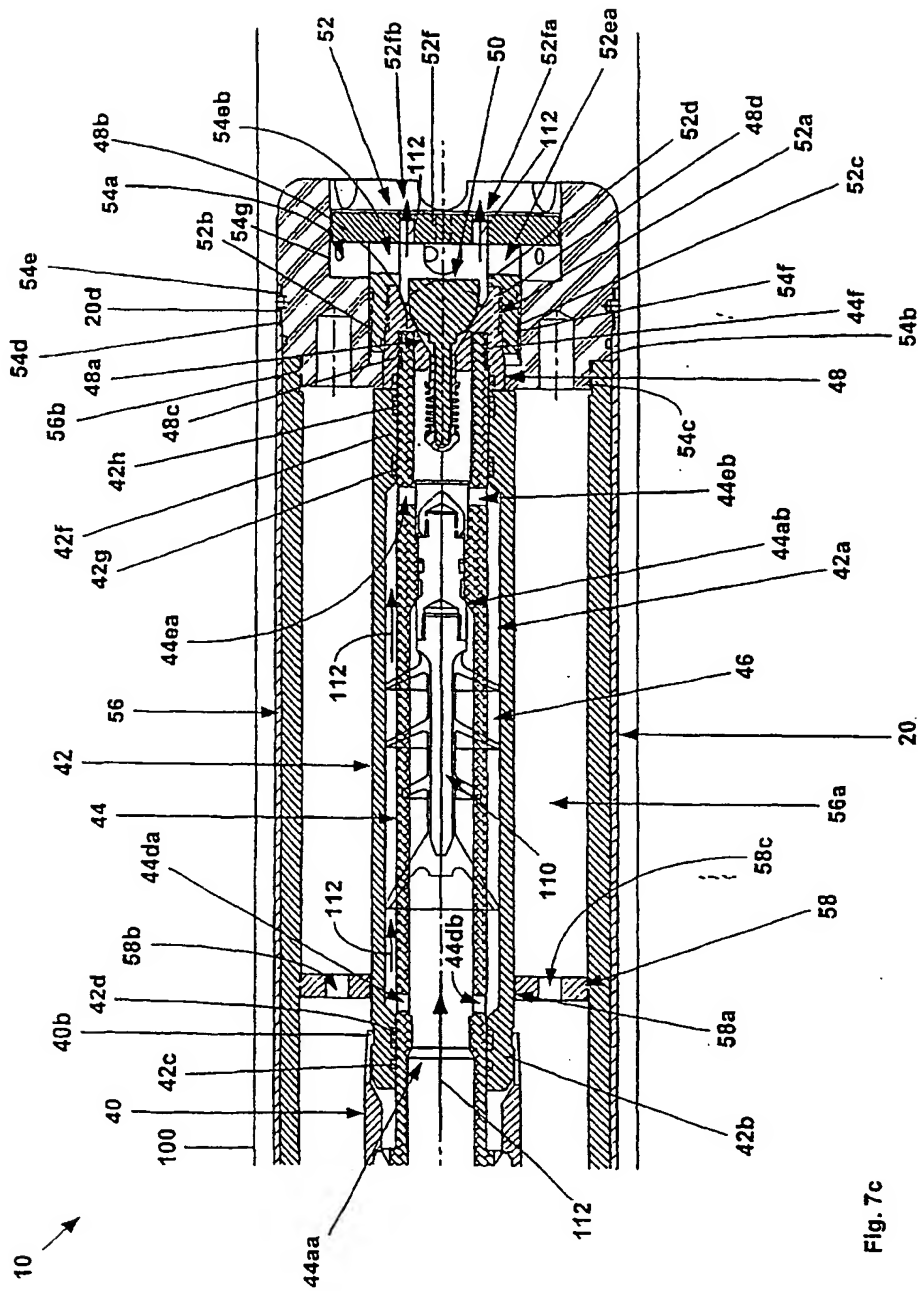


Fig. 7c

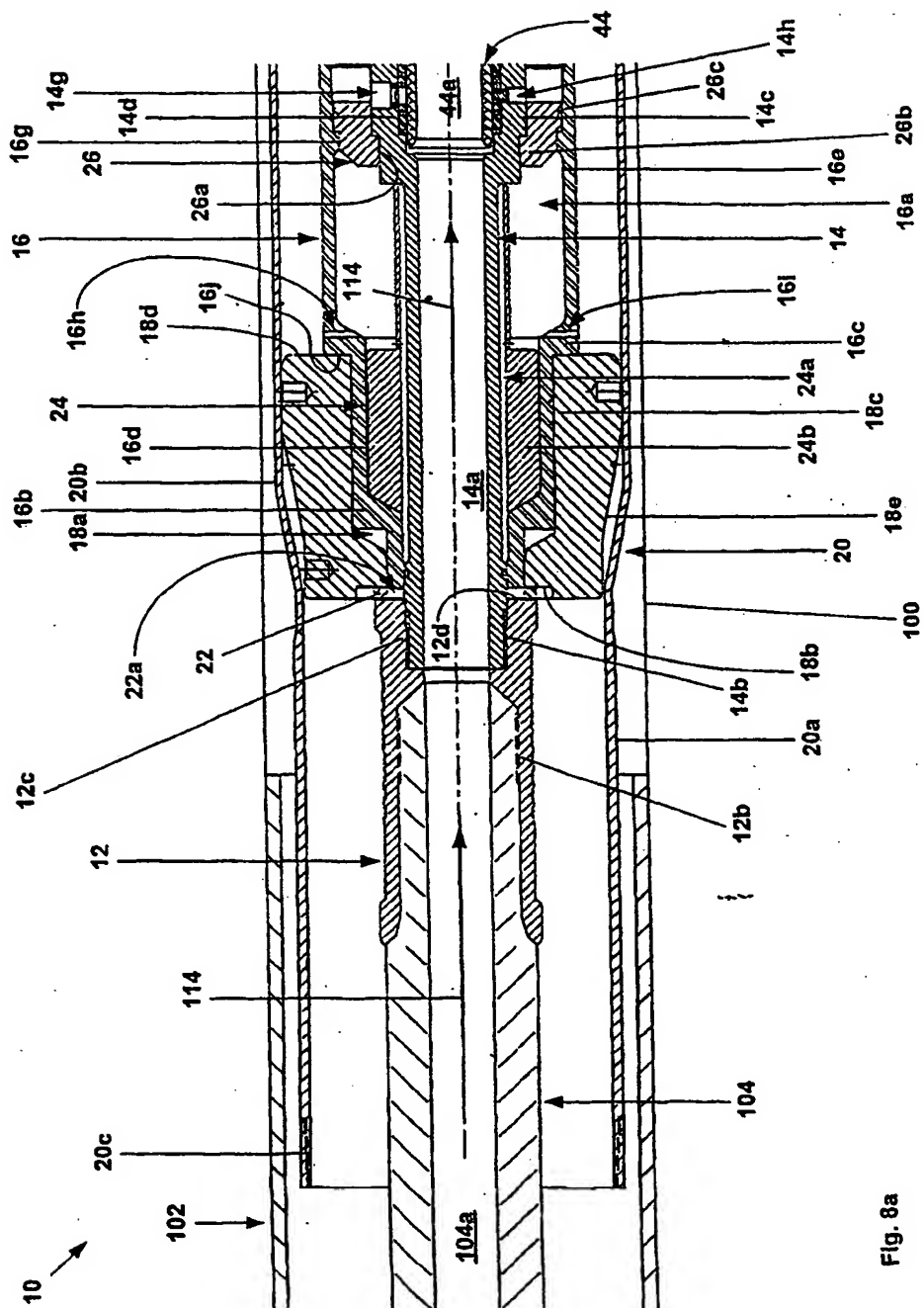


Fig. 8a

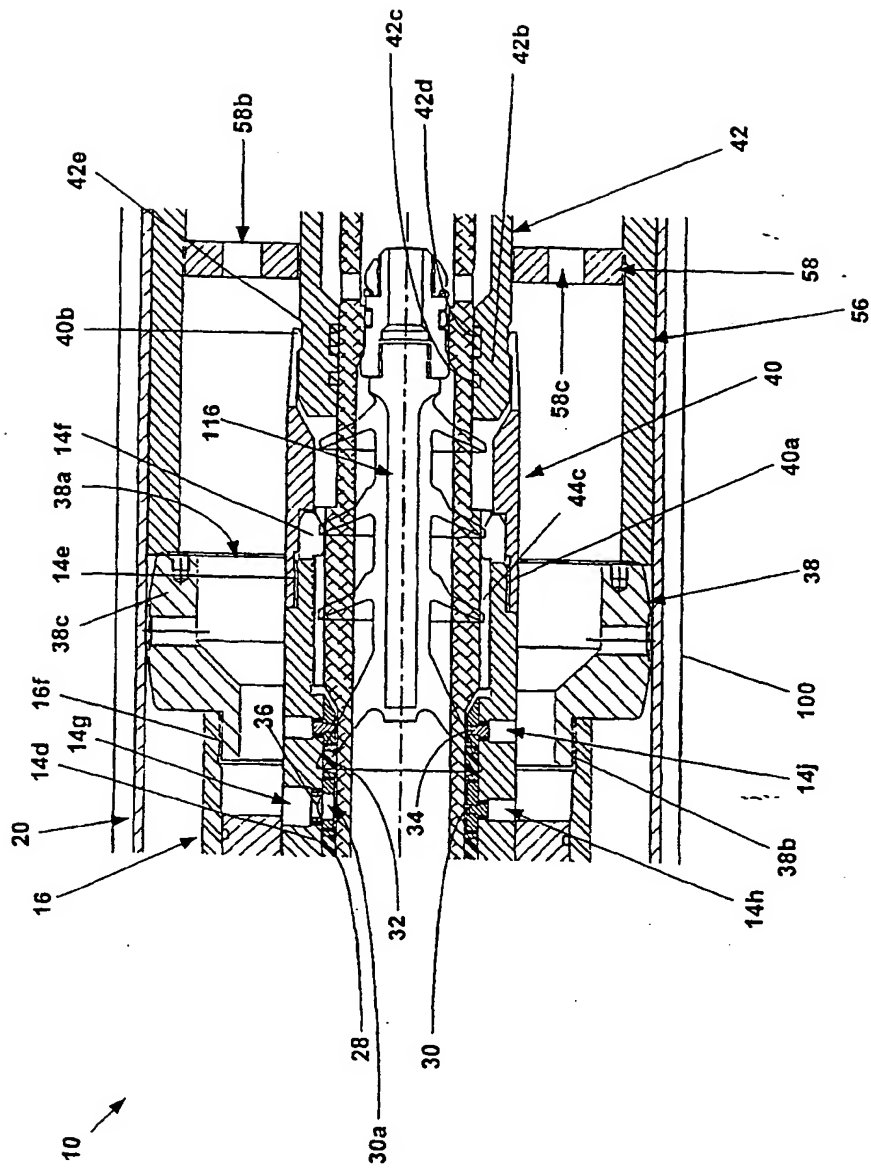


Fig. 8b

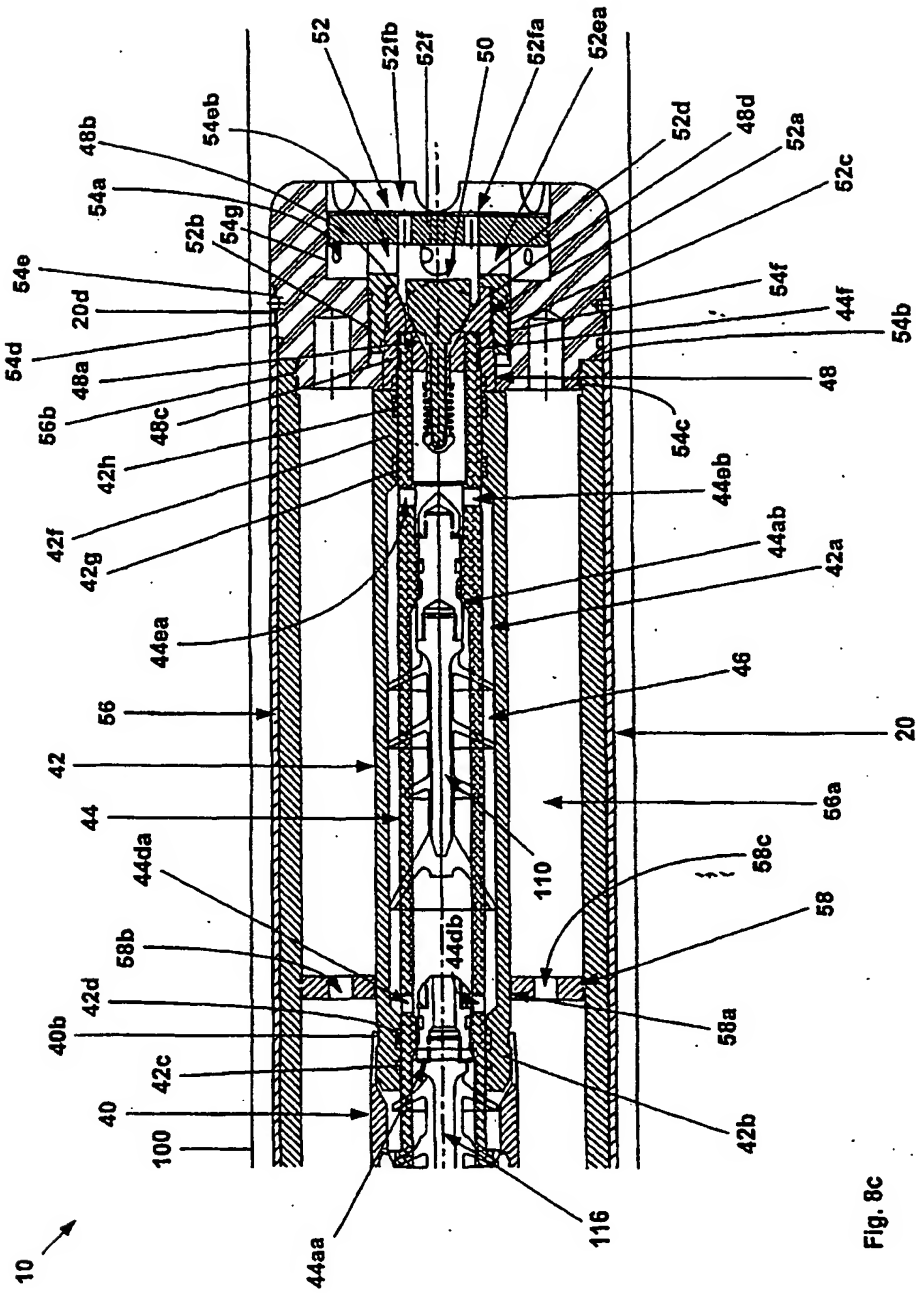


Fig. 8c

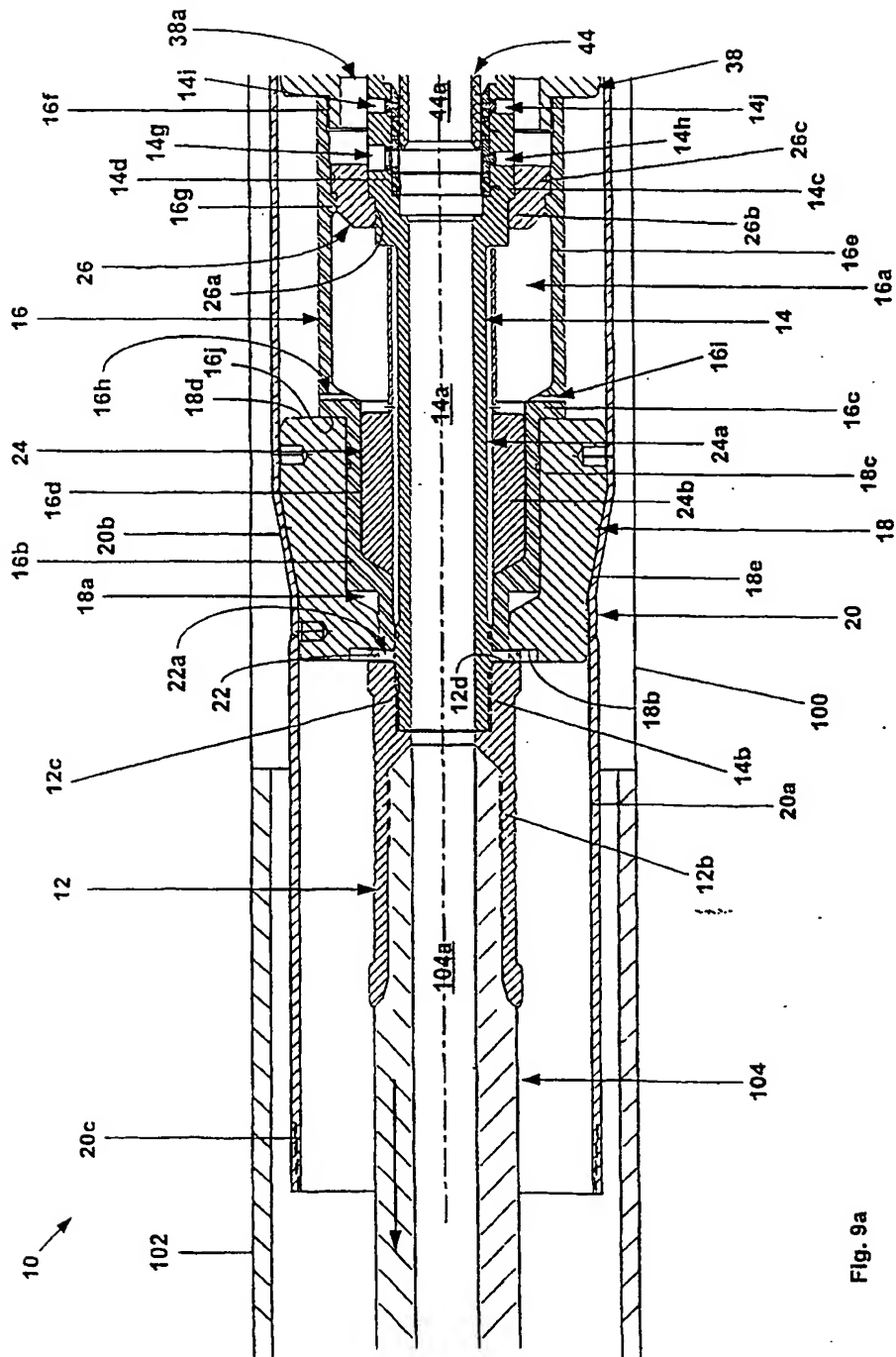


Fig. 9a

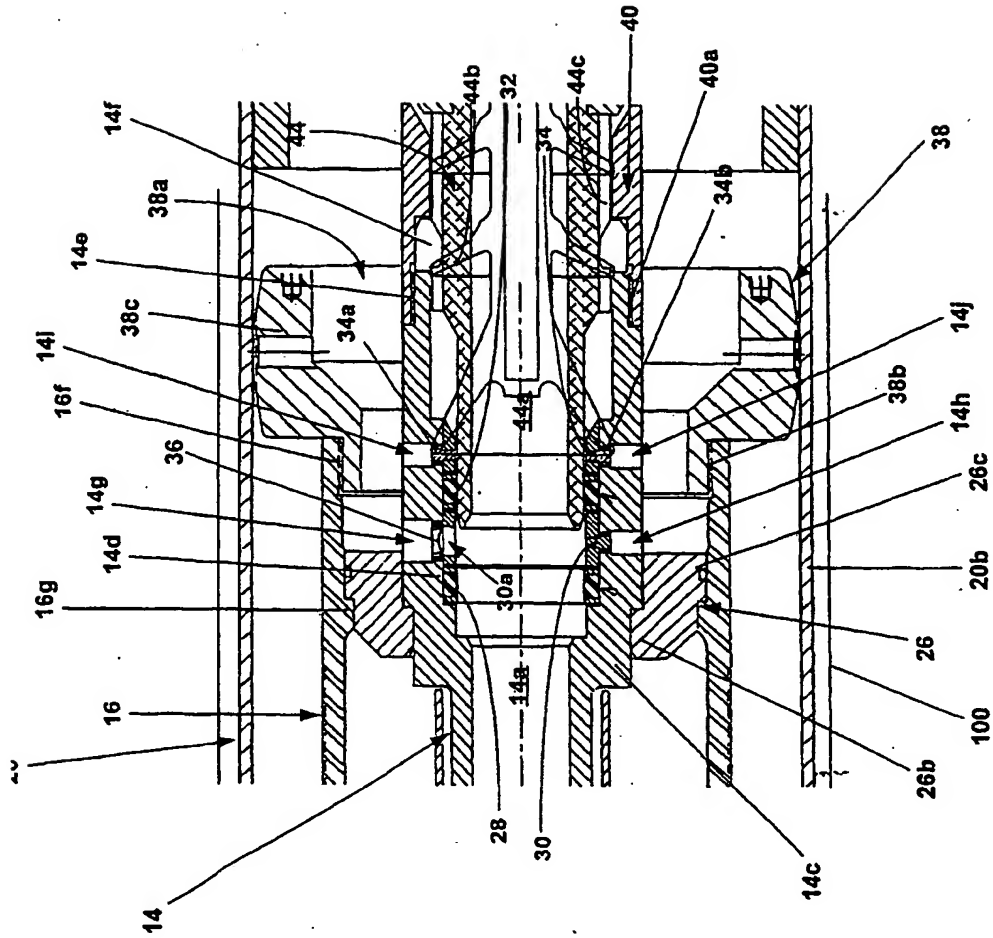
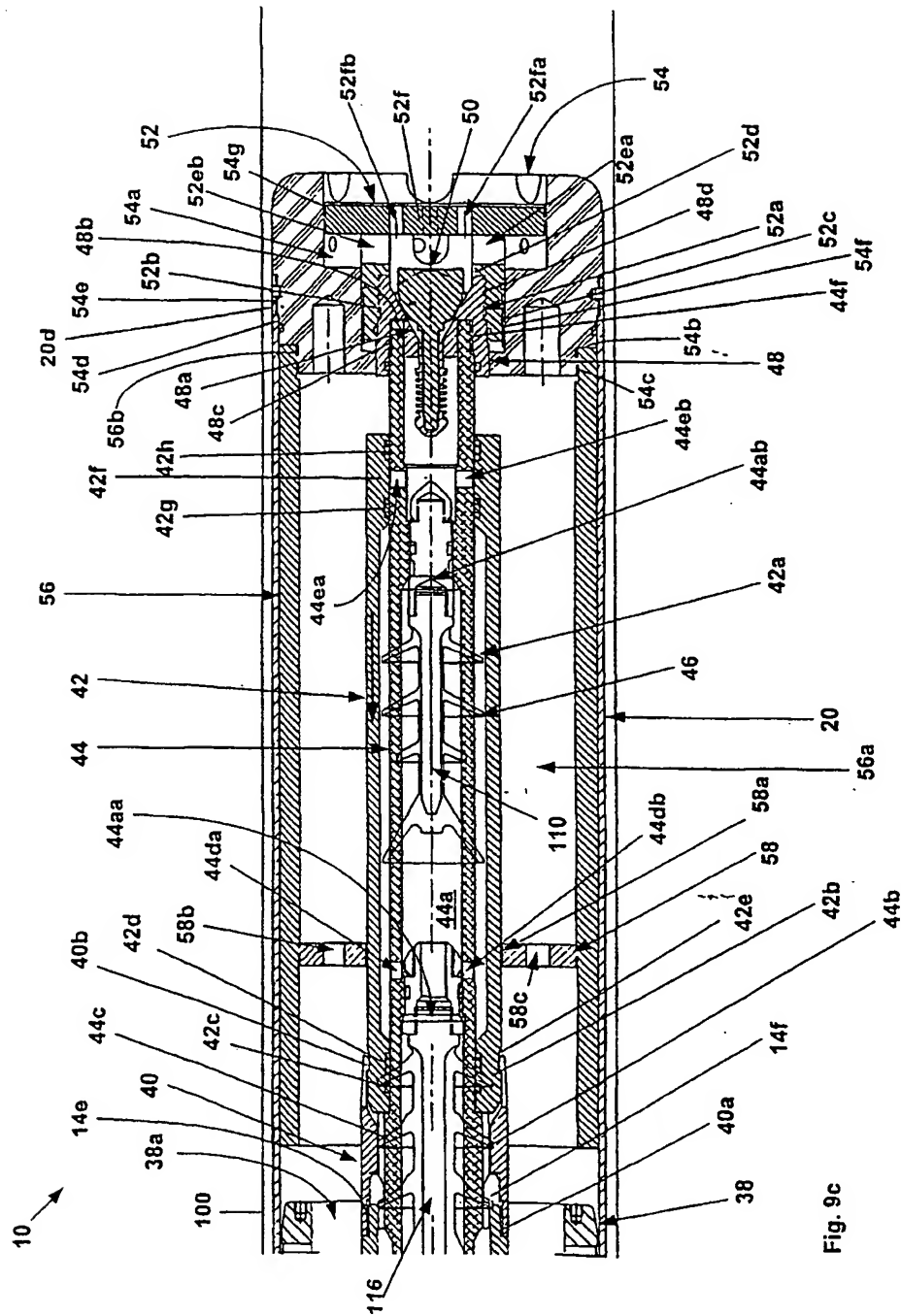


Fig. 9b

10 →





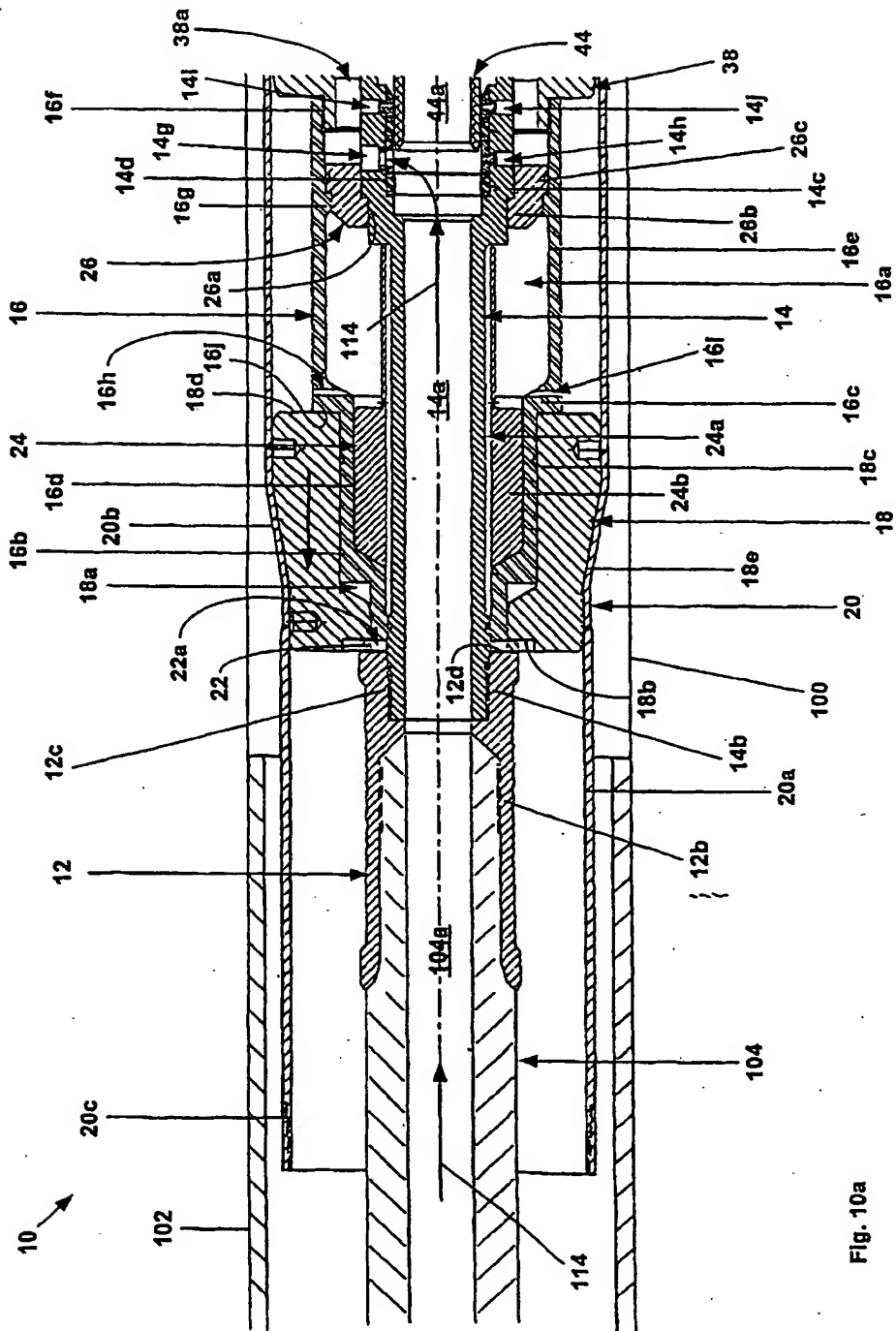


Fig. 10a

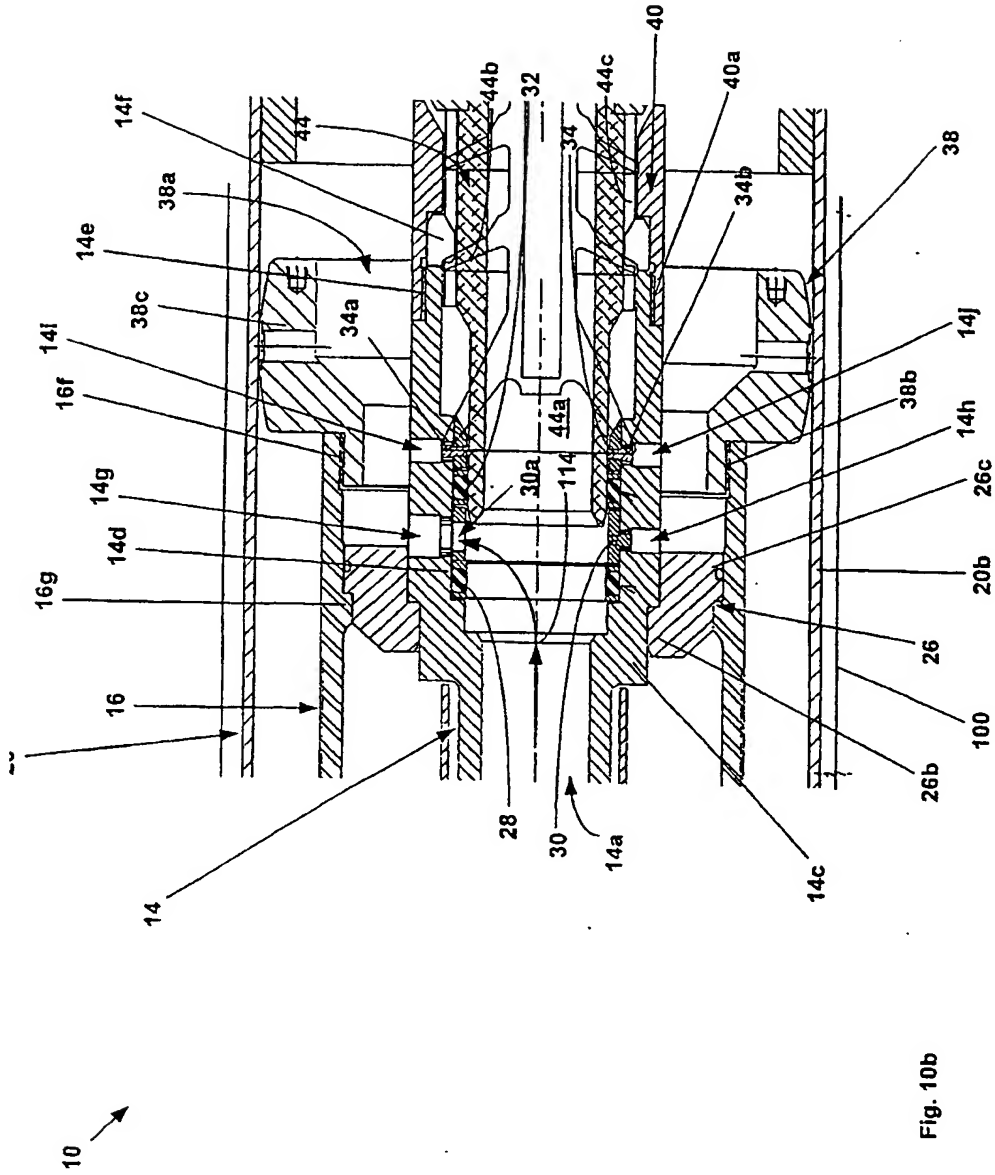
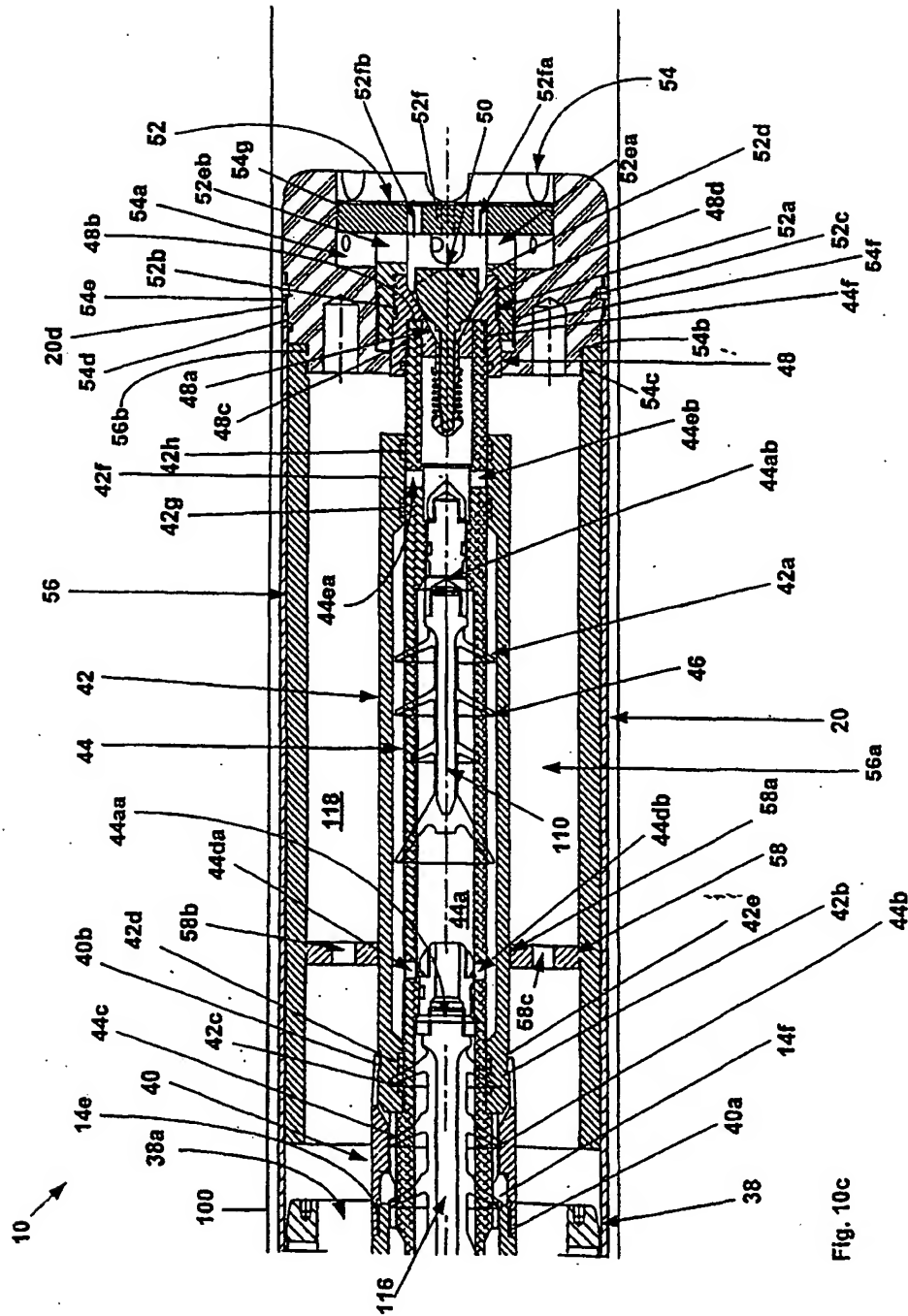


Fig. 10b



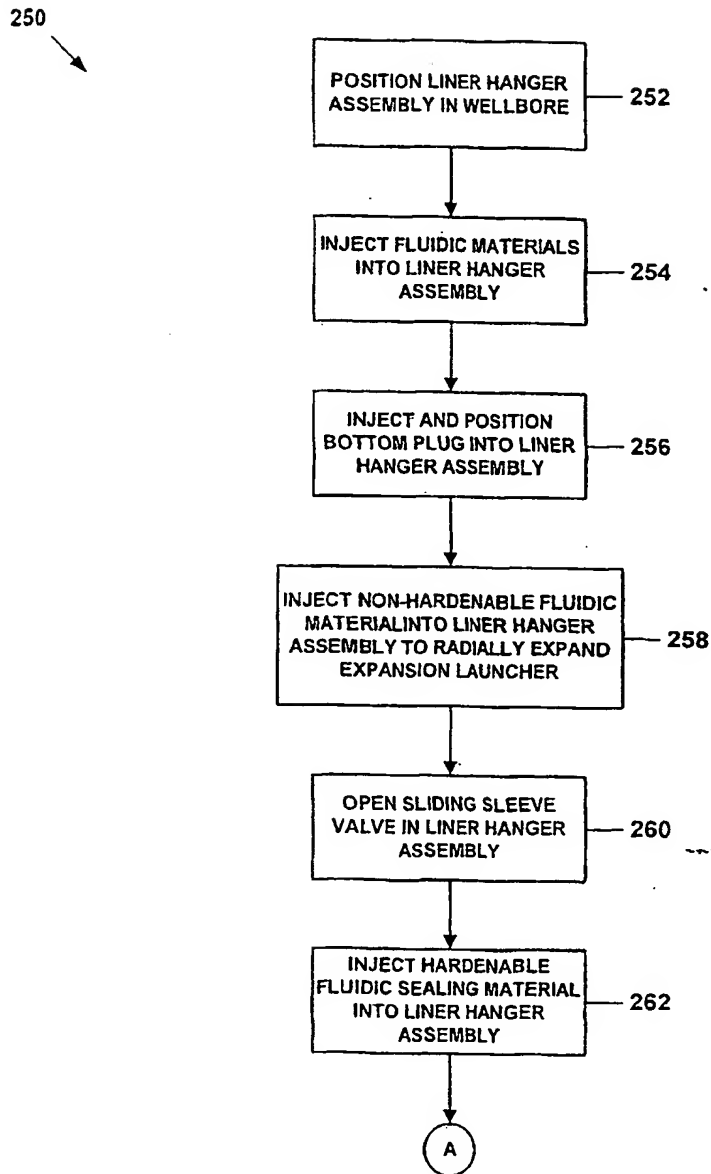


Fig. 11a

250

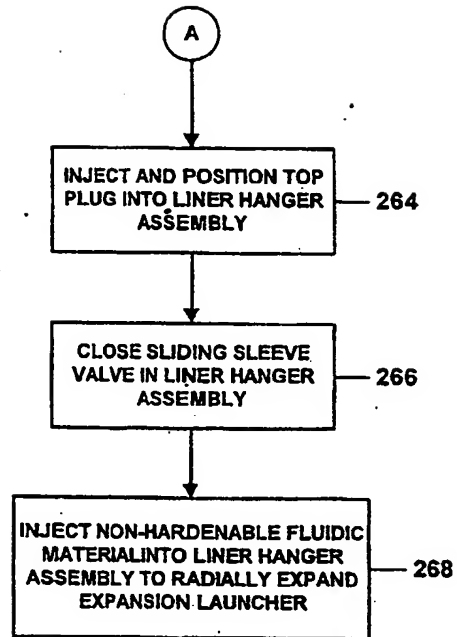


Fig. 11b

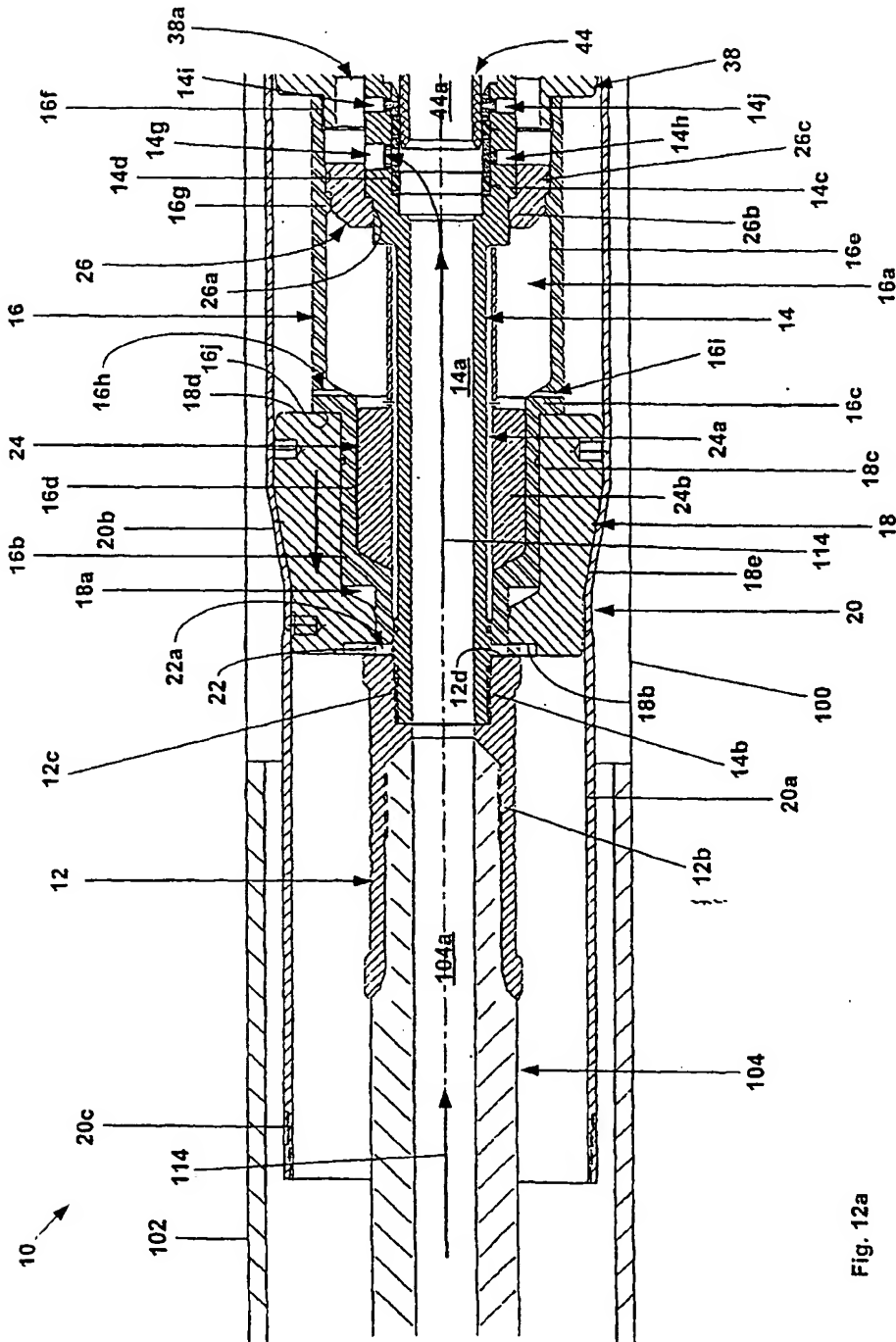


Fig. 12a

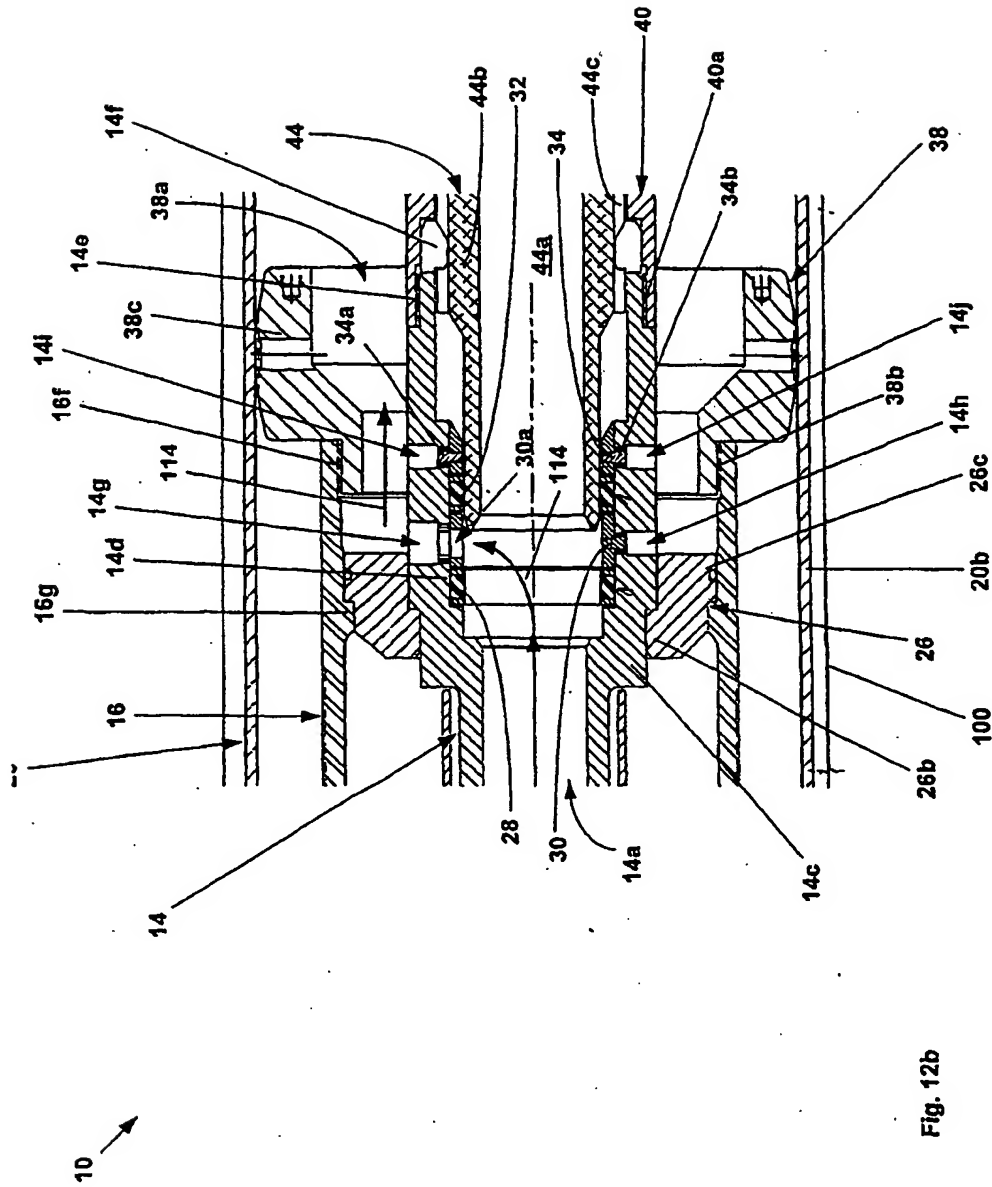


Fig. 12b



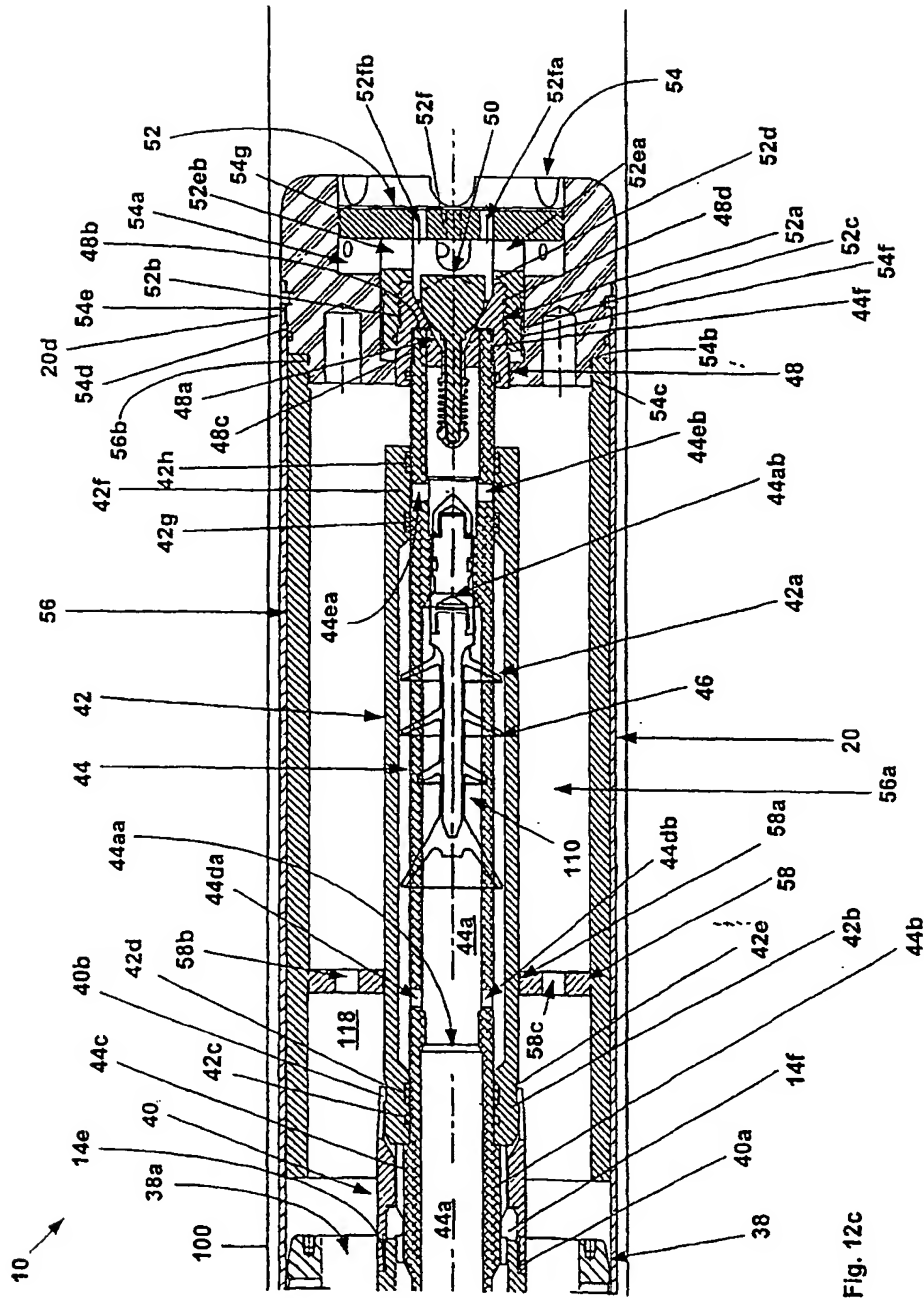


Fig. 12c

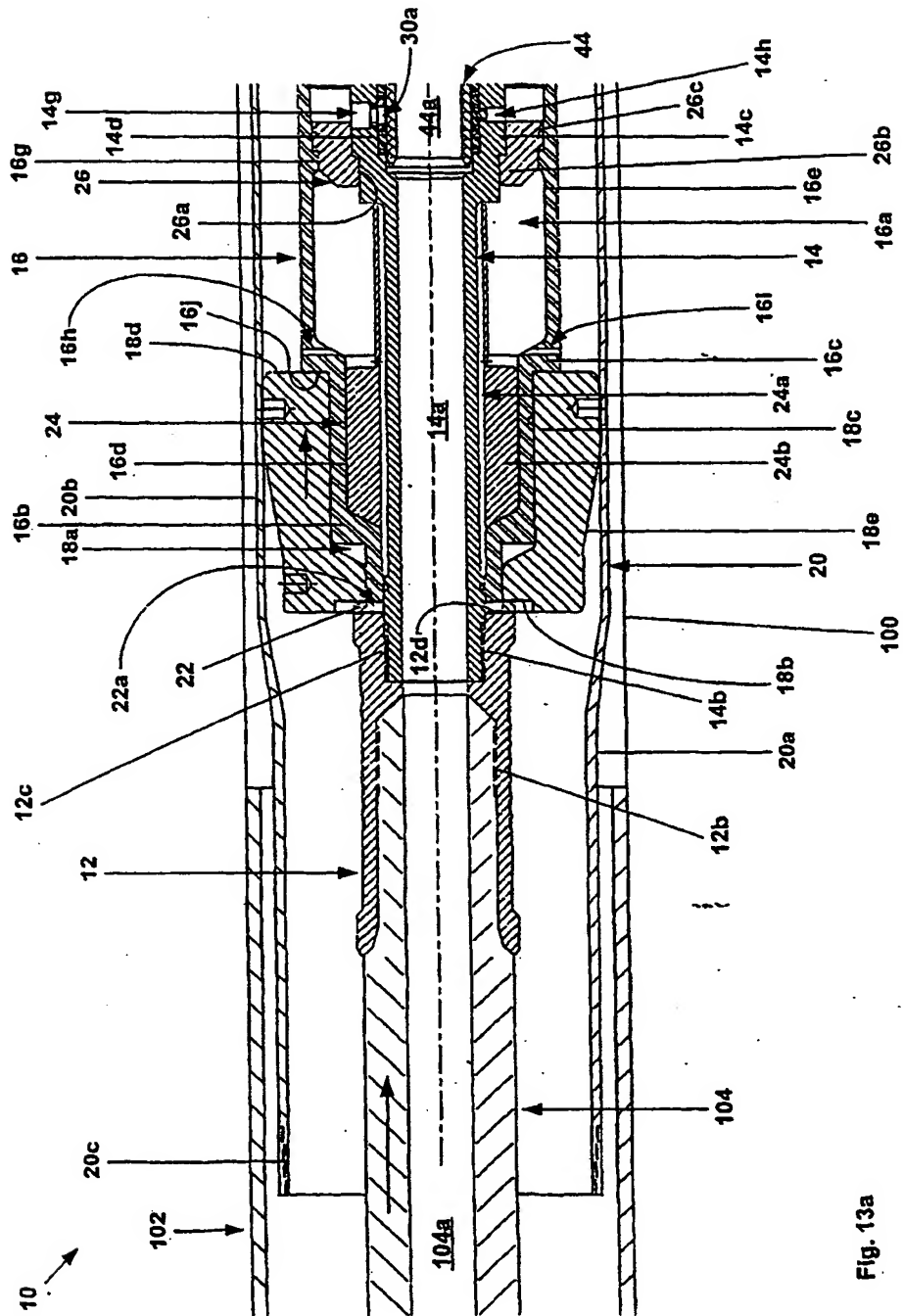


Fig. 13a

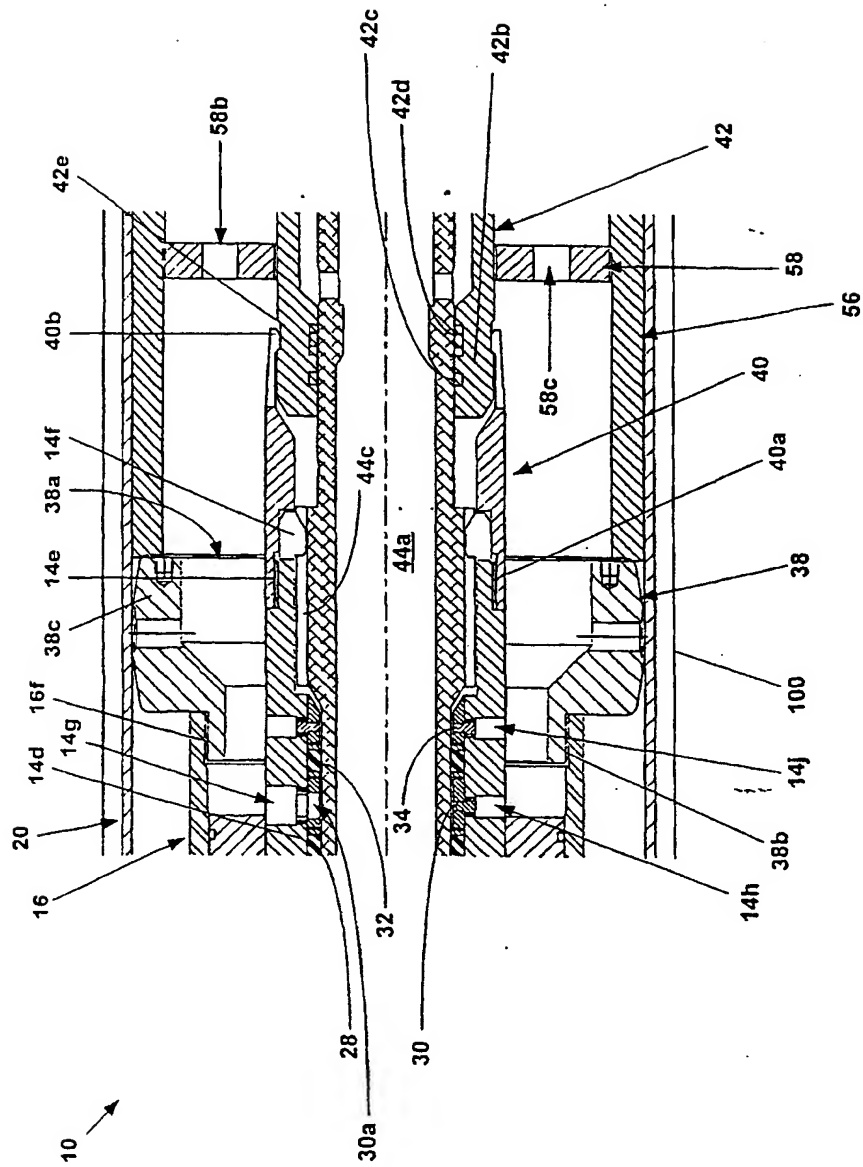
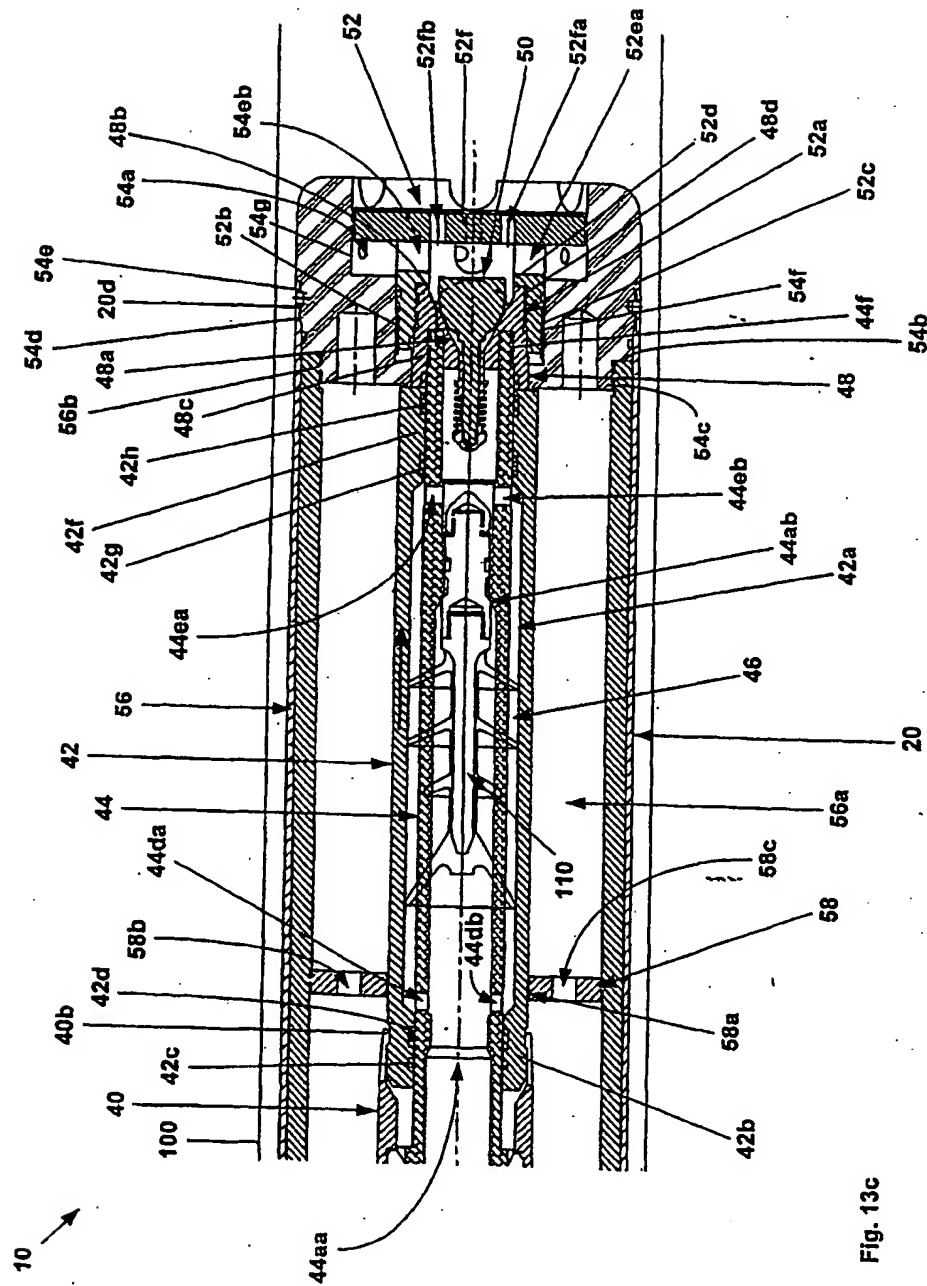
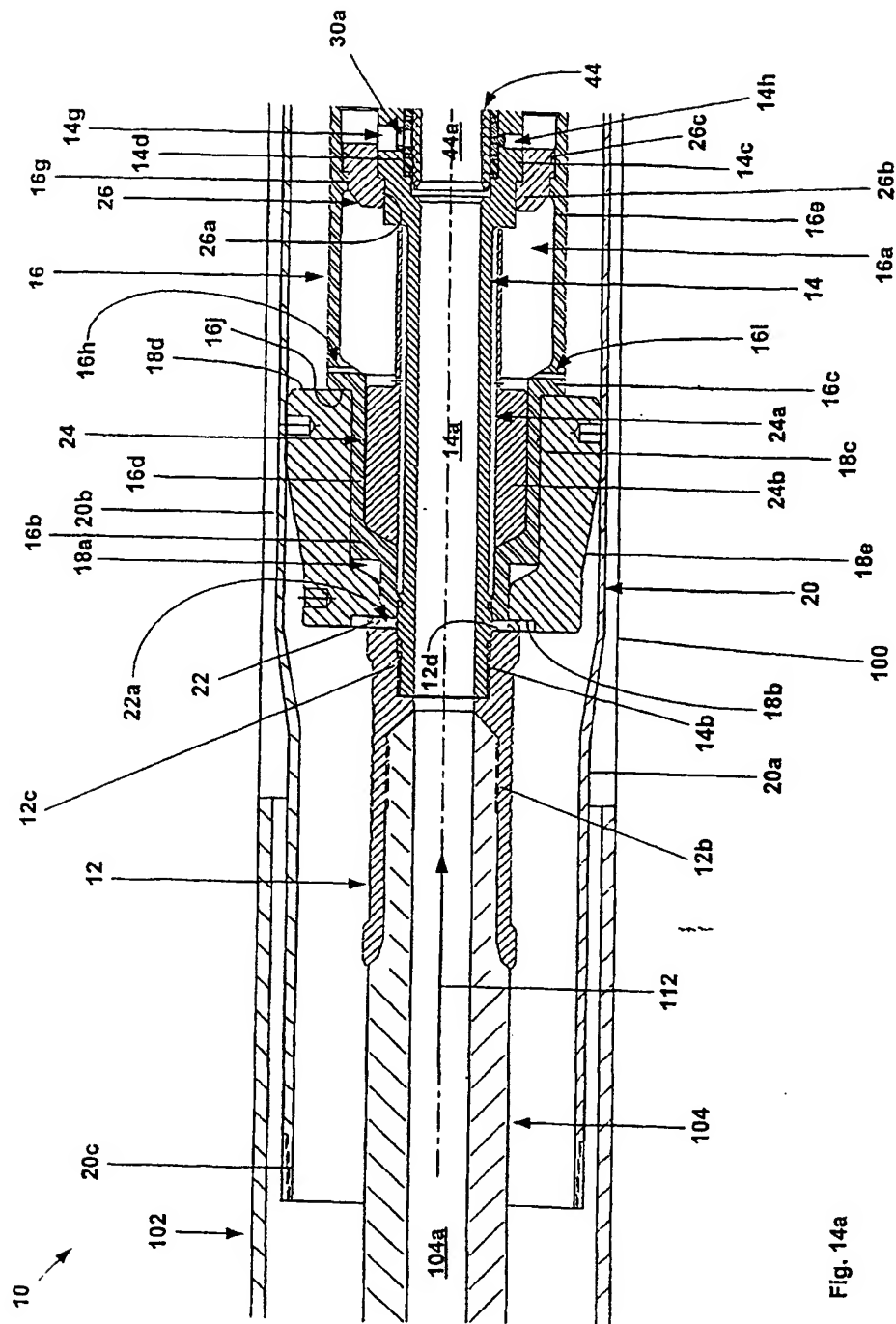


Fig. 13b





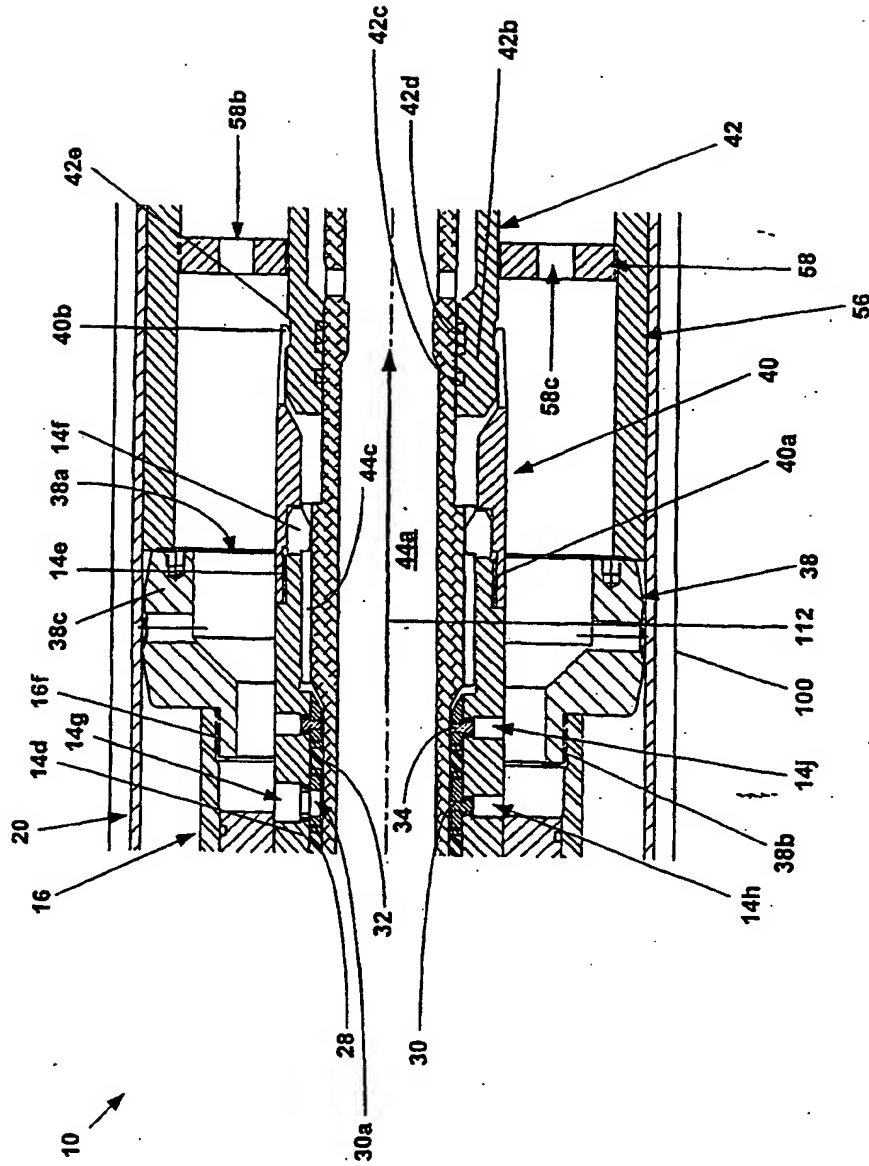


Fig. 14b

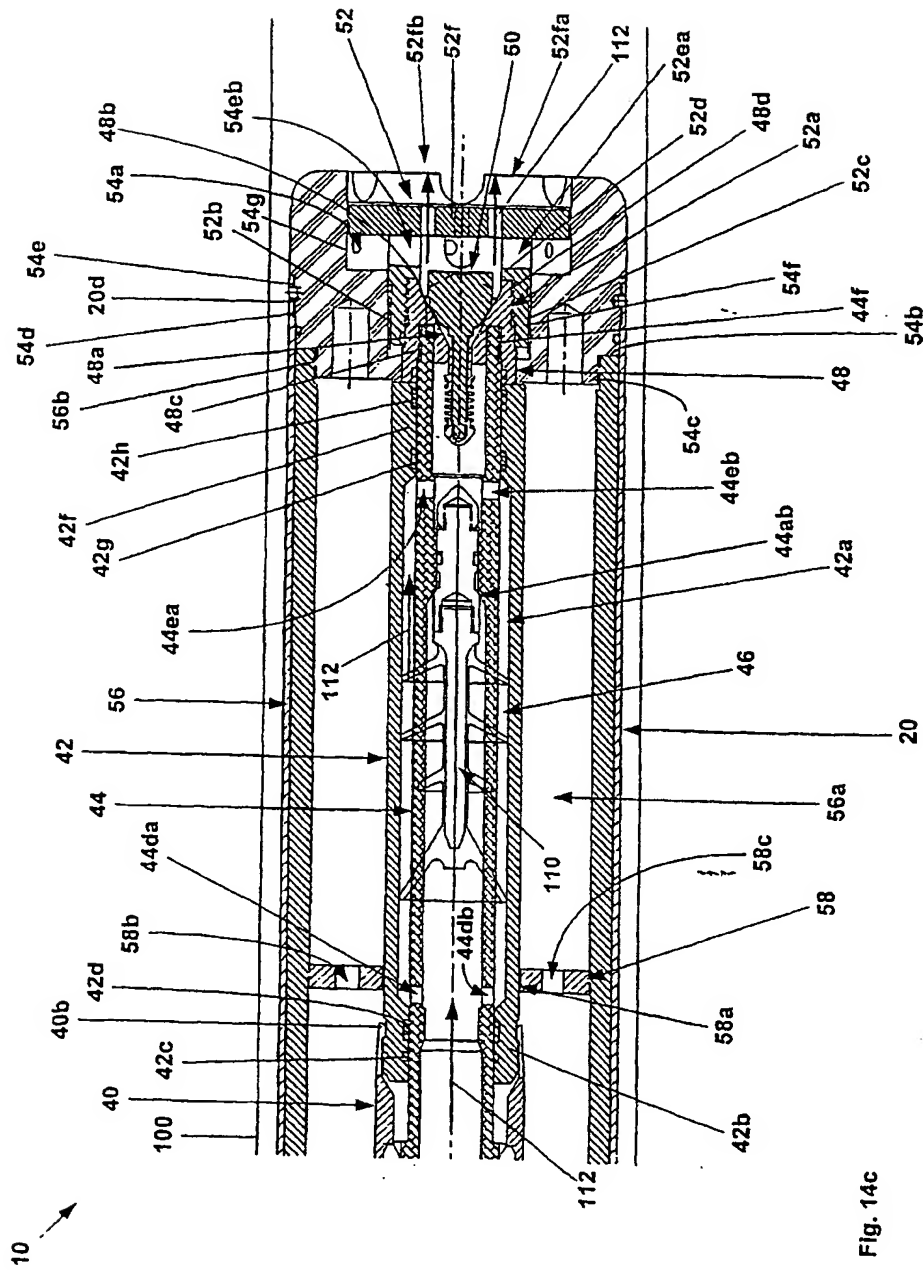


Fig. 14c

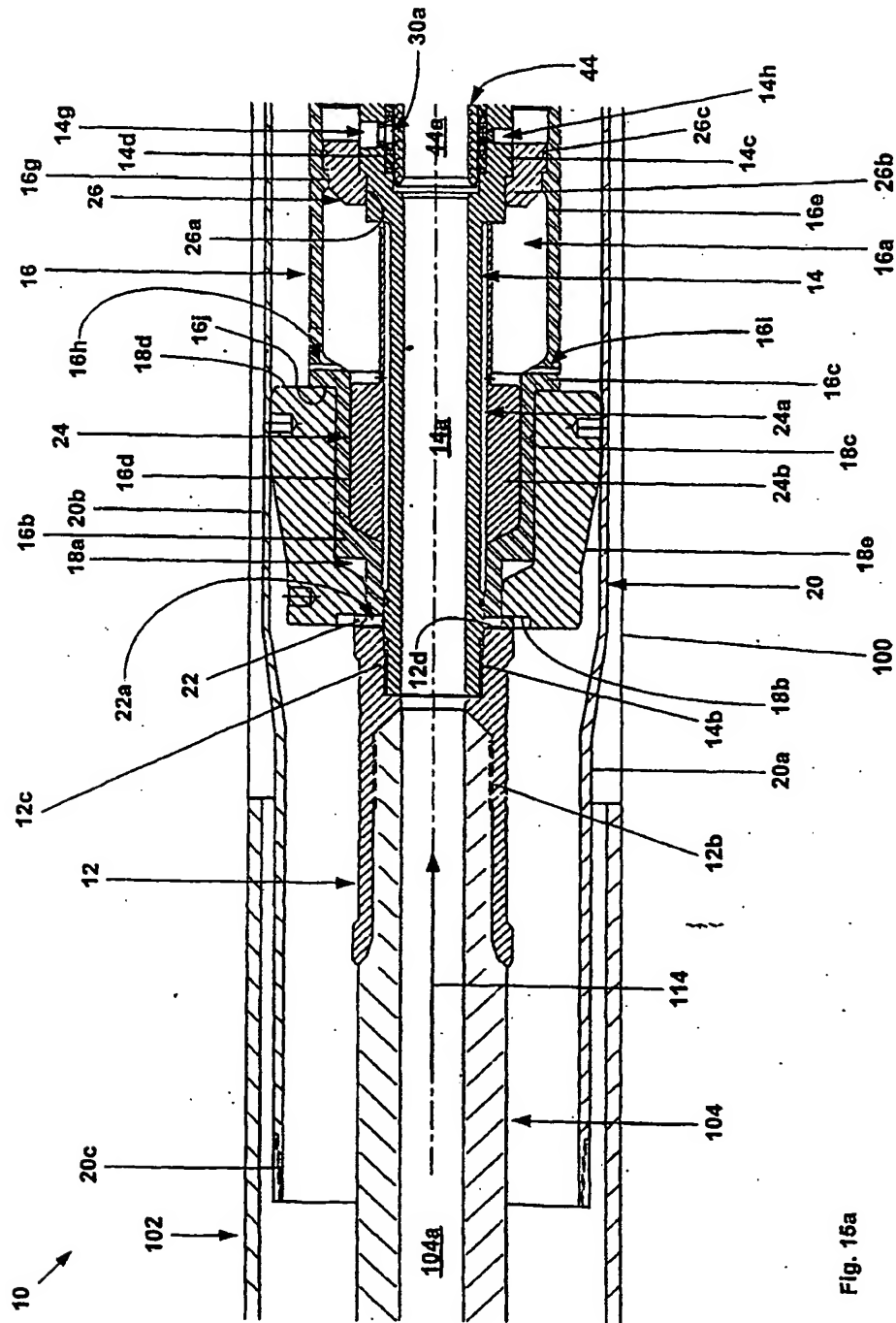


Fig. 15a



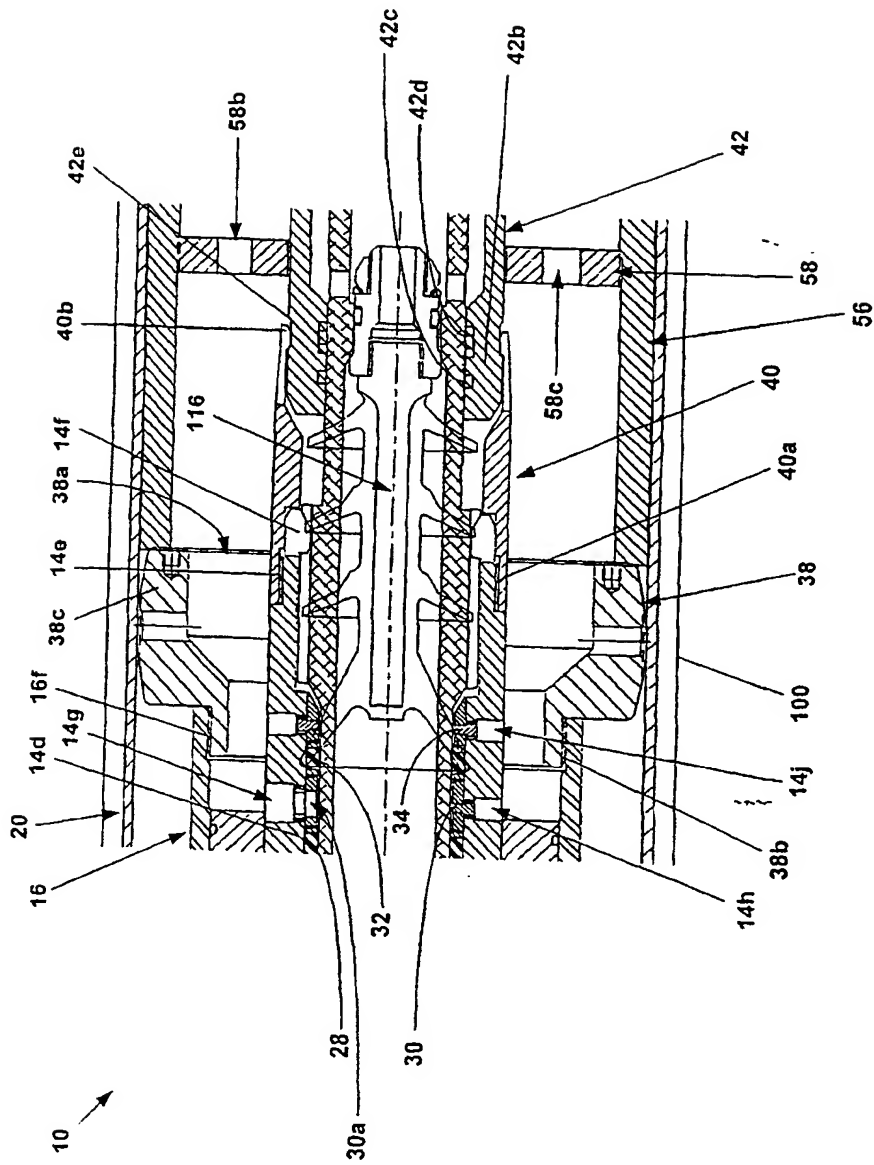


Fig. 15b

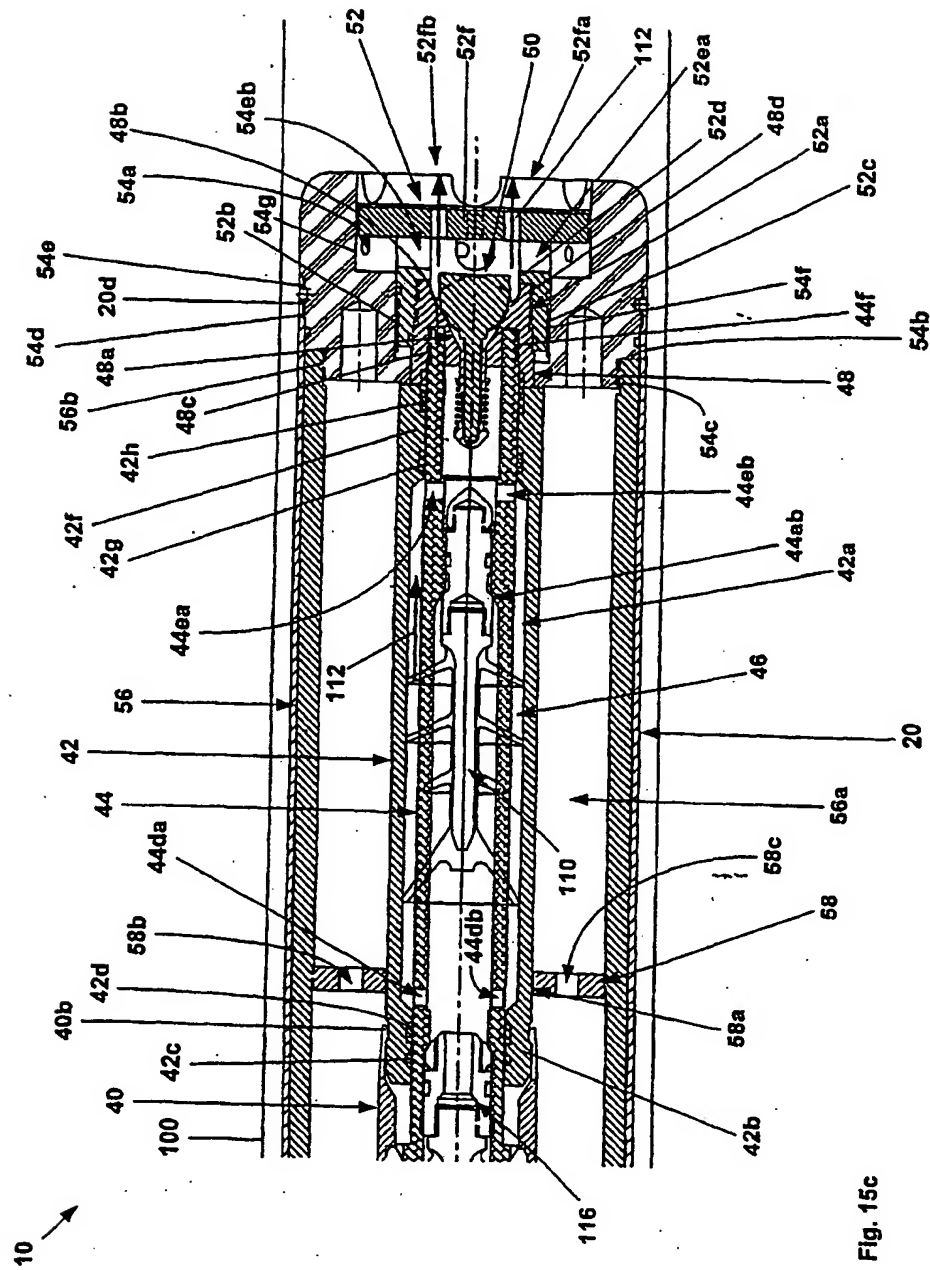


Fig. 15c

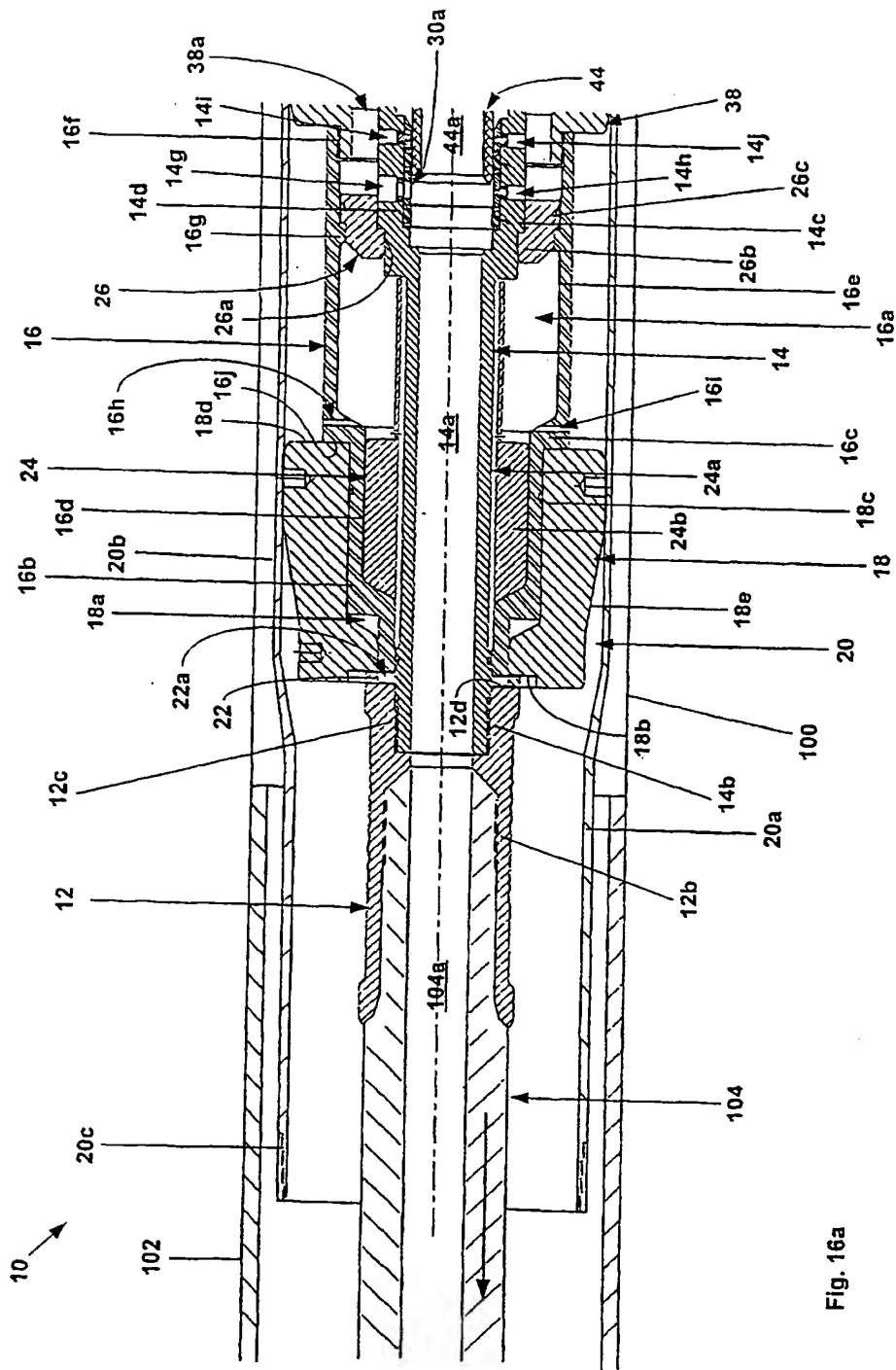
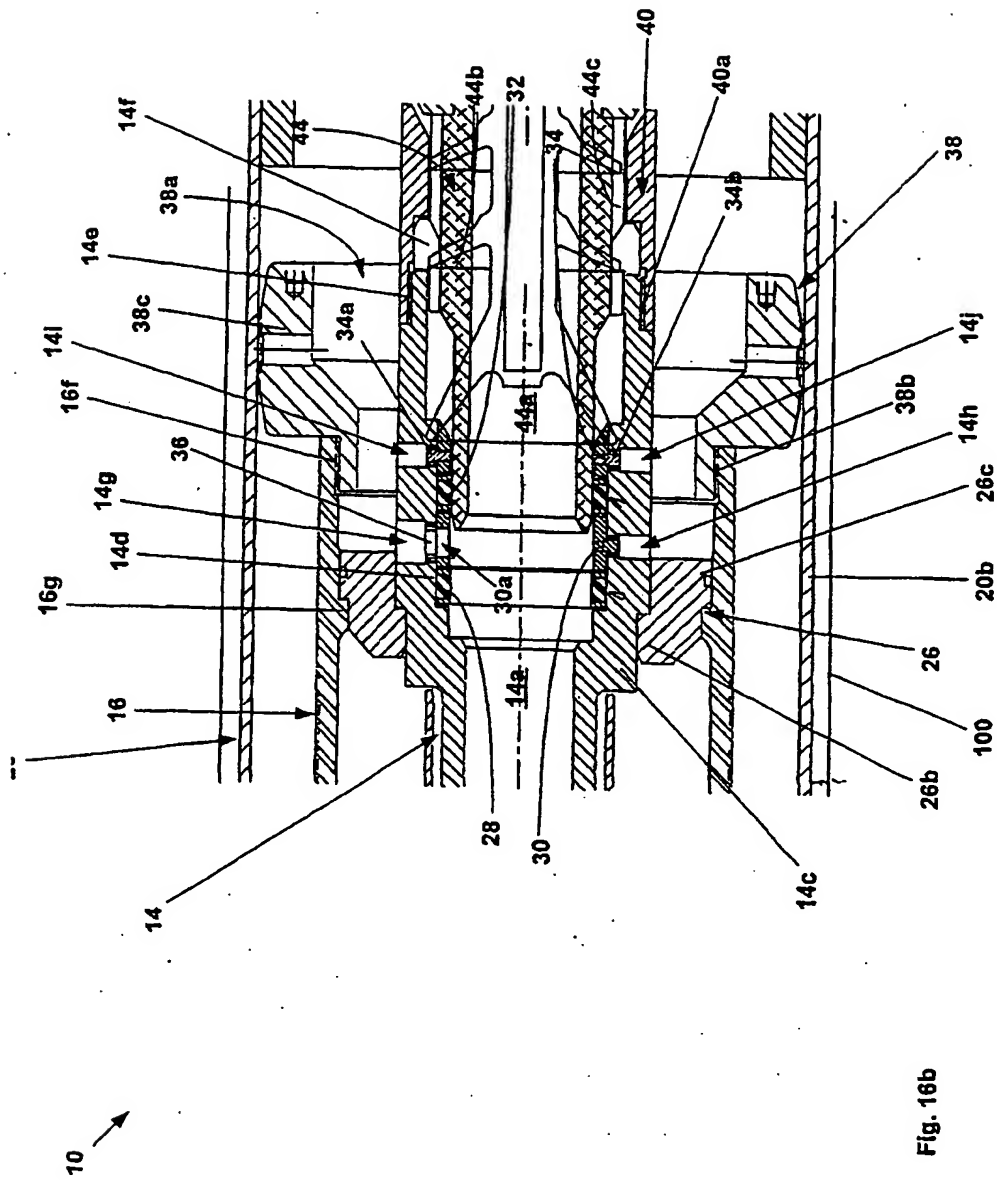


Fig. 16a



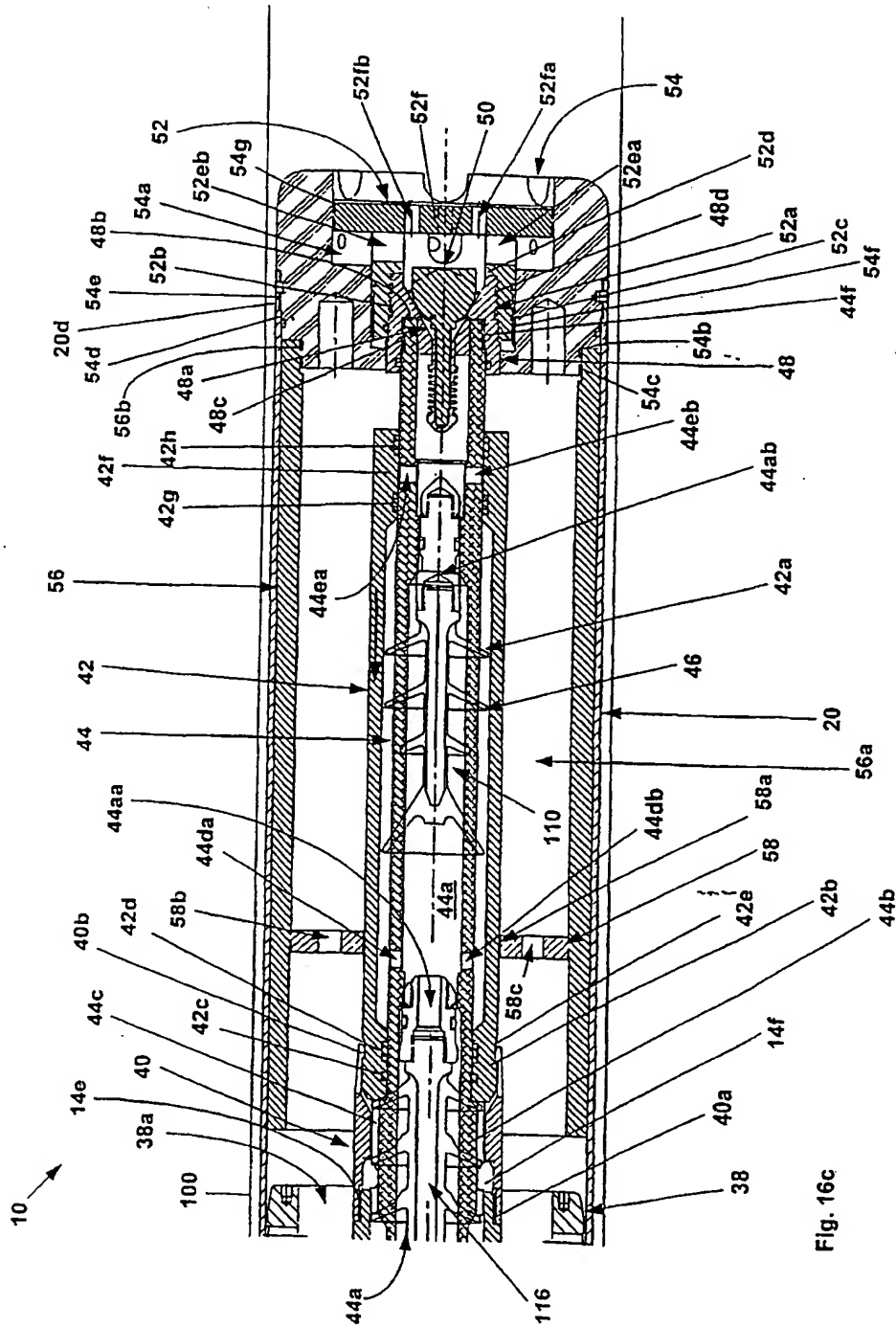


Fig. 16c

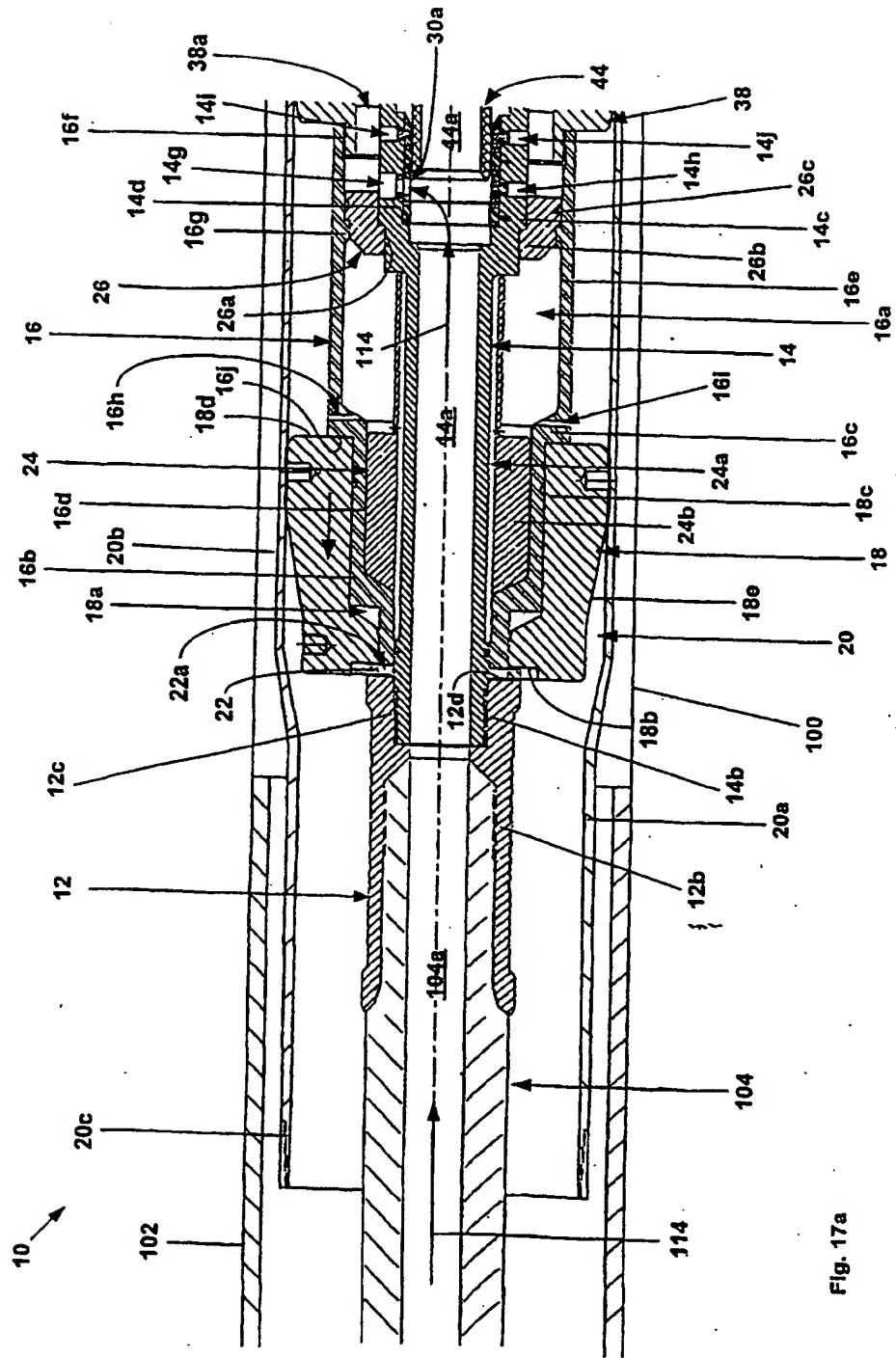
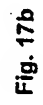


Fig. 17a







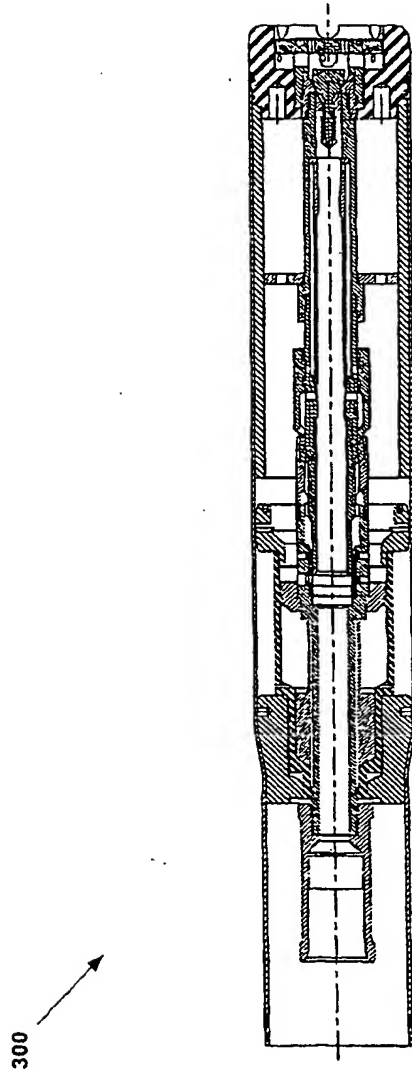


Fig. 18

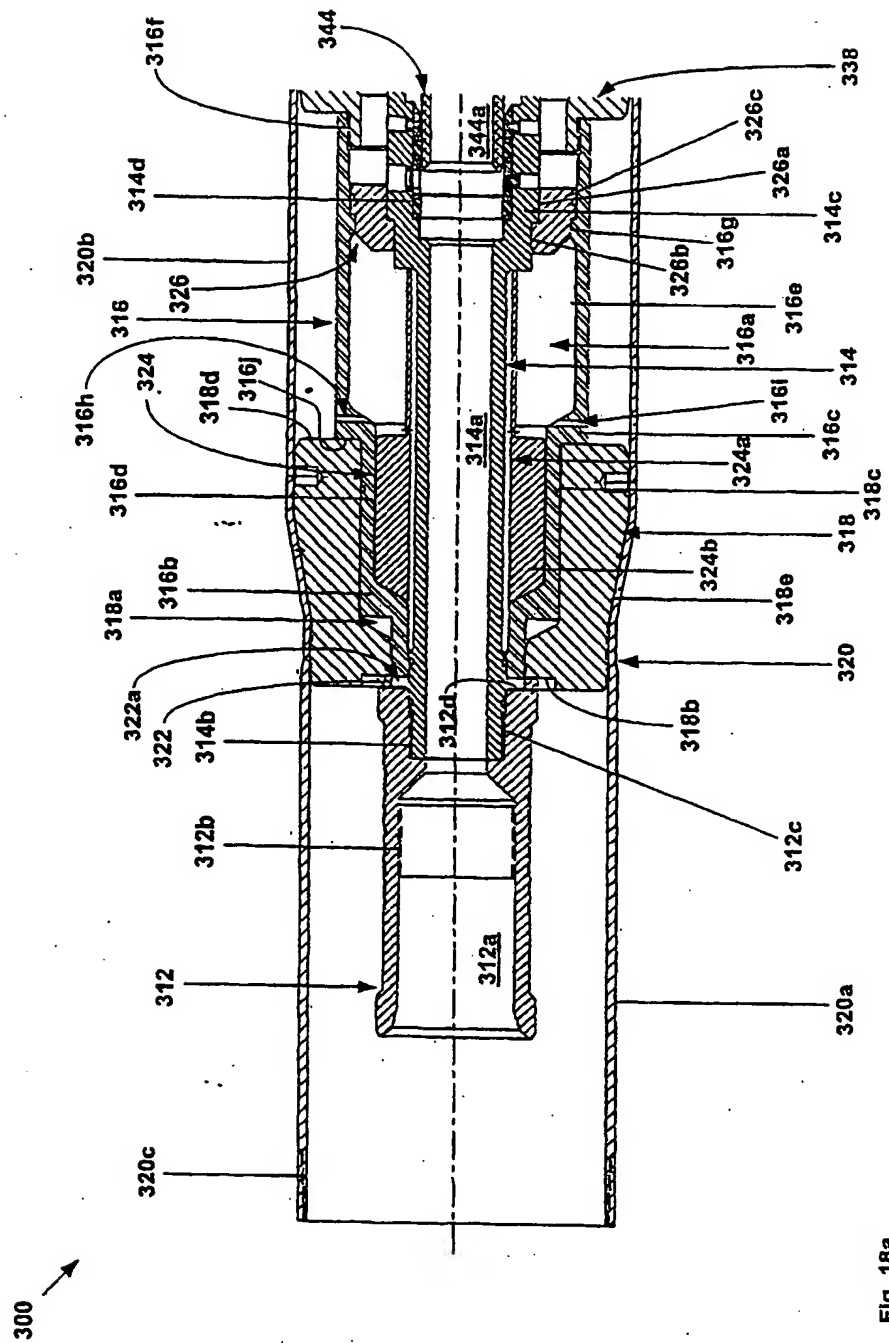
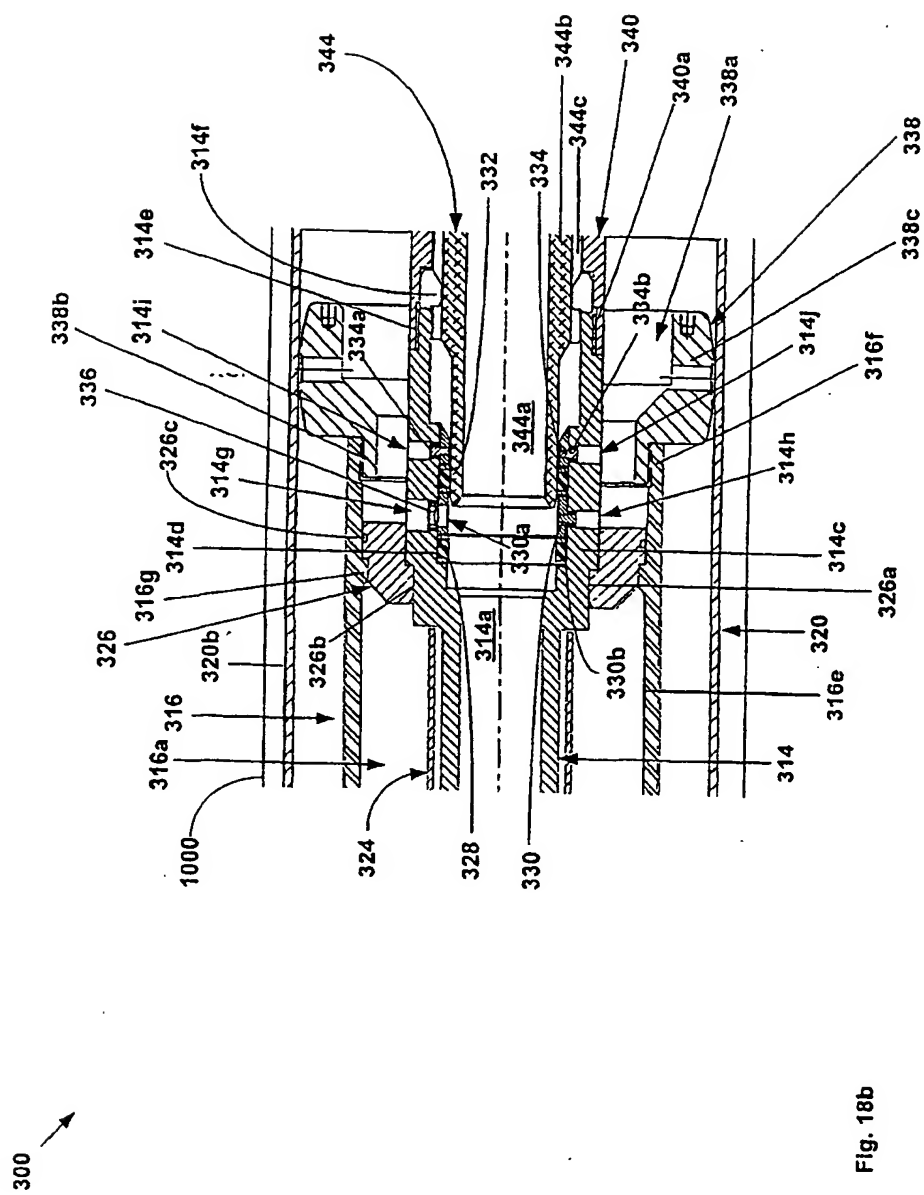
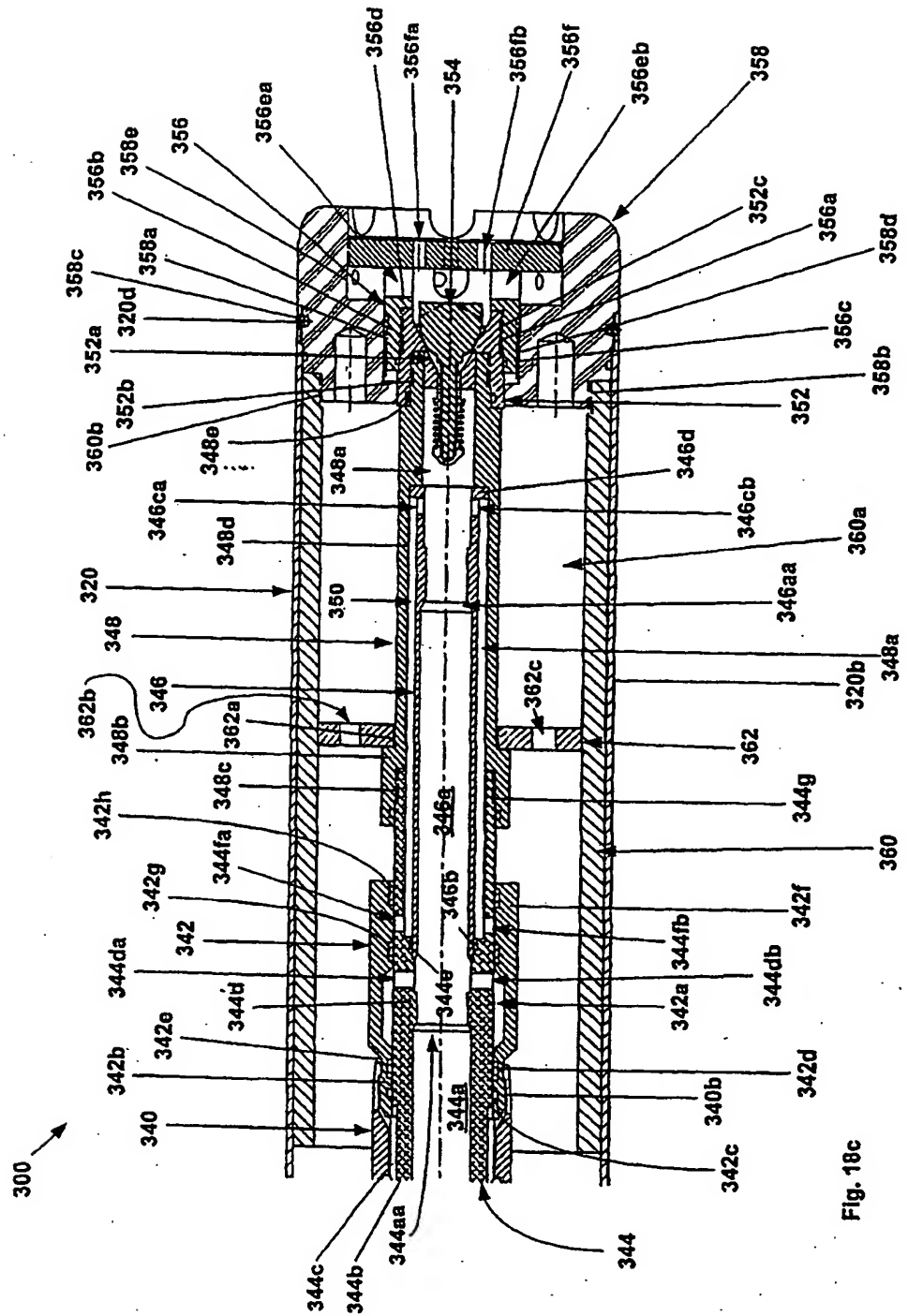


Fig. 18a





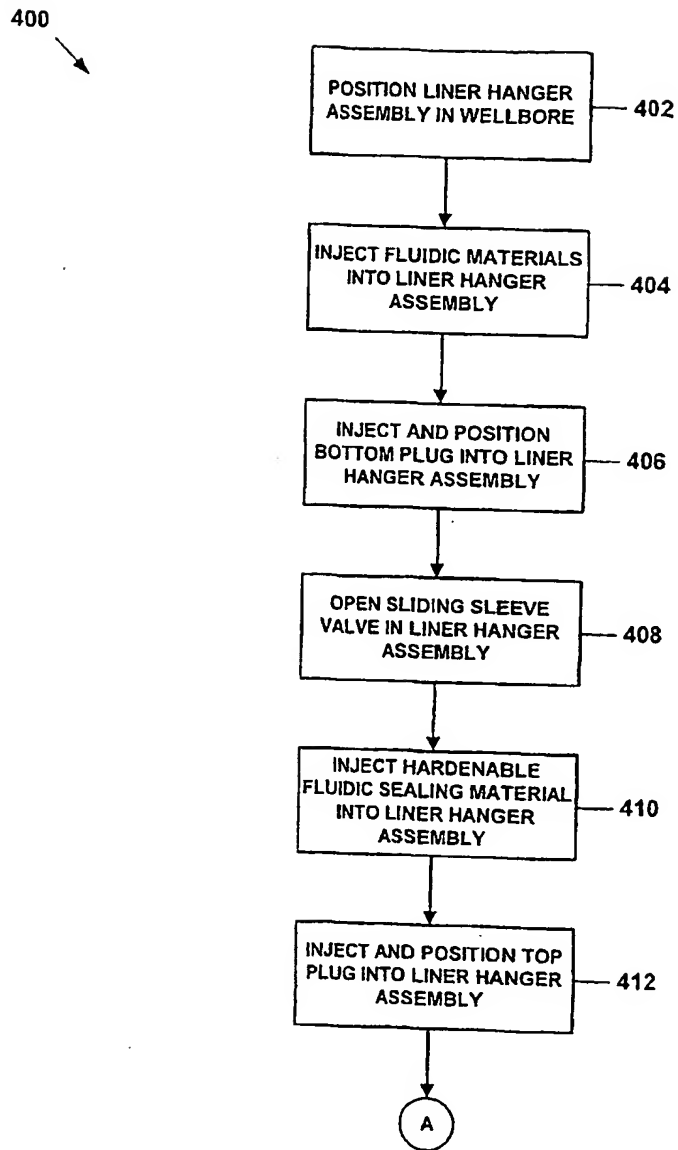


Fig. 19a

400

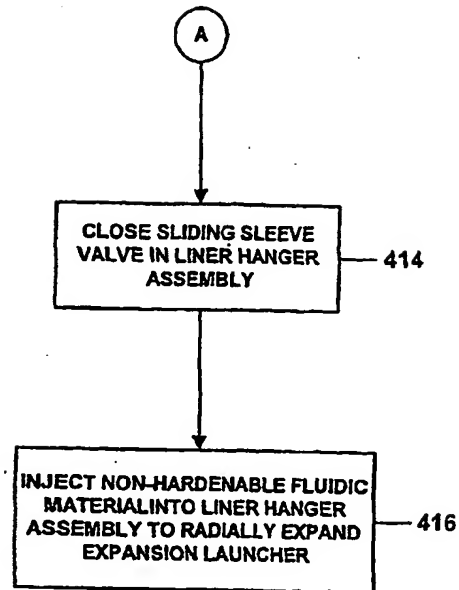


Fig. 19b

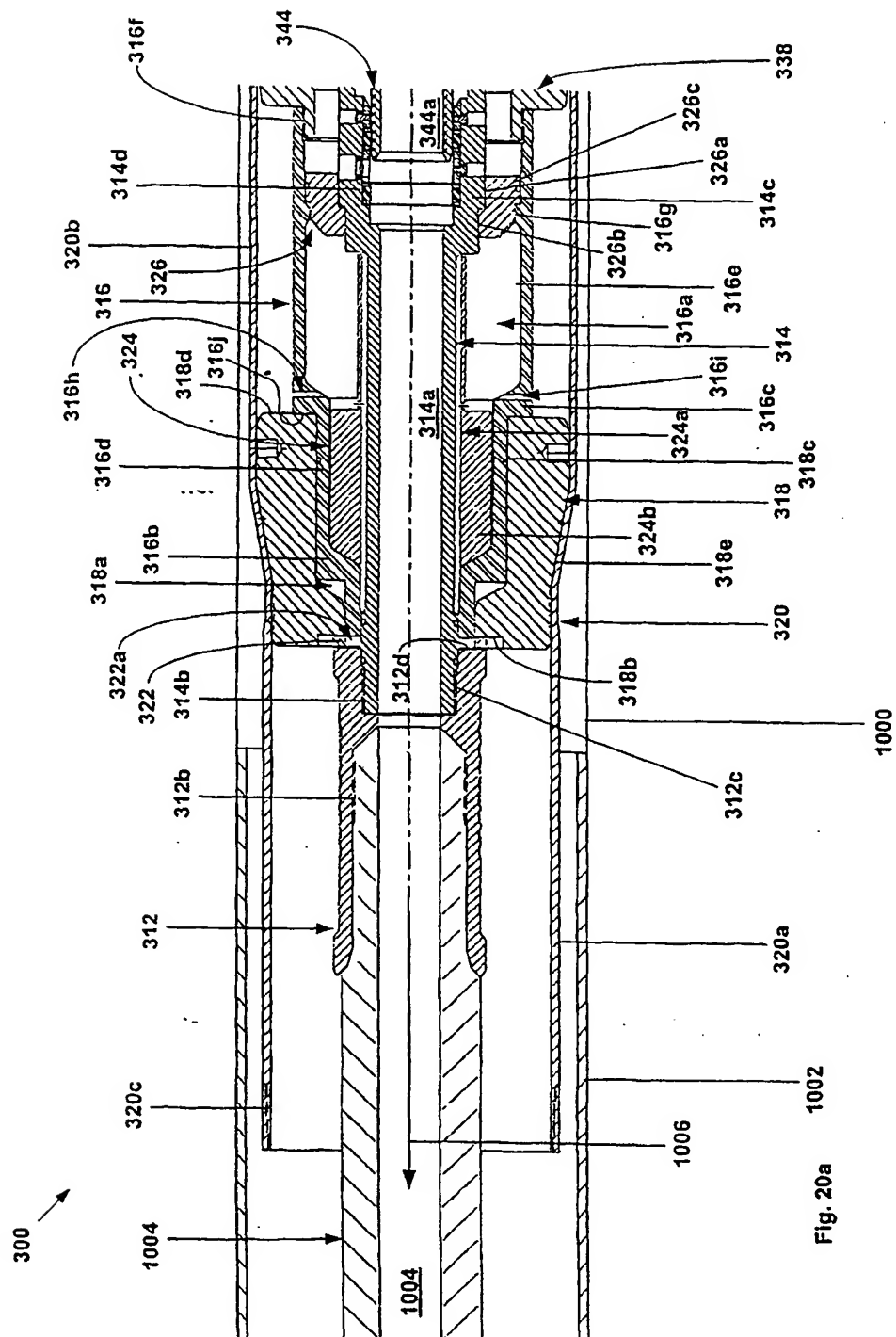
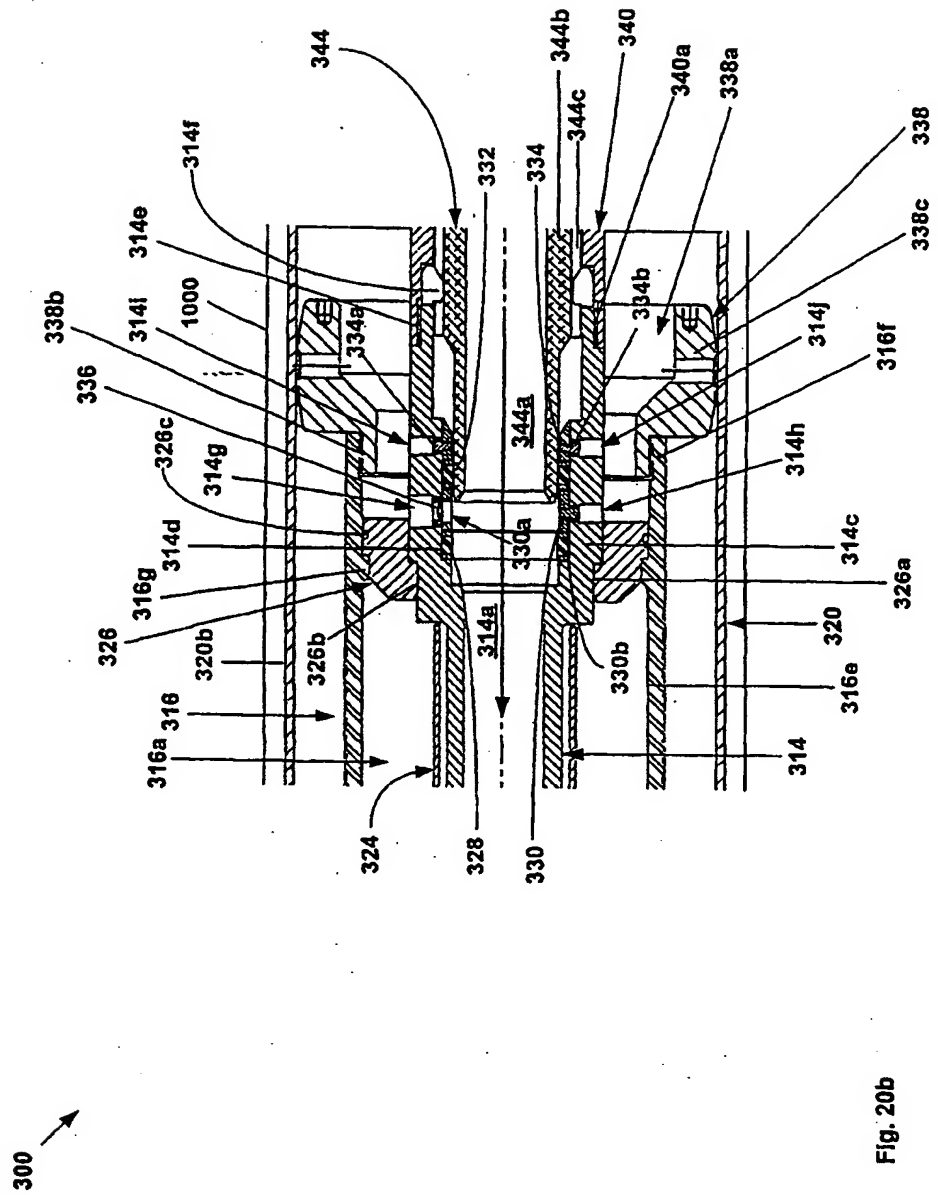


Fig. 20a





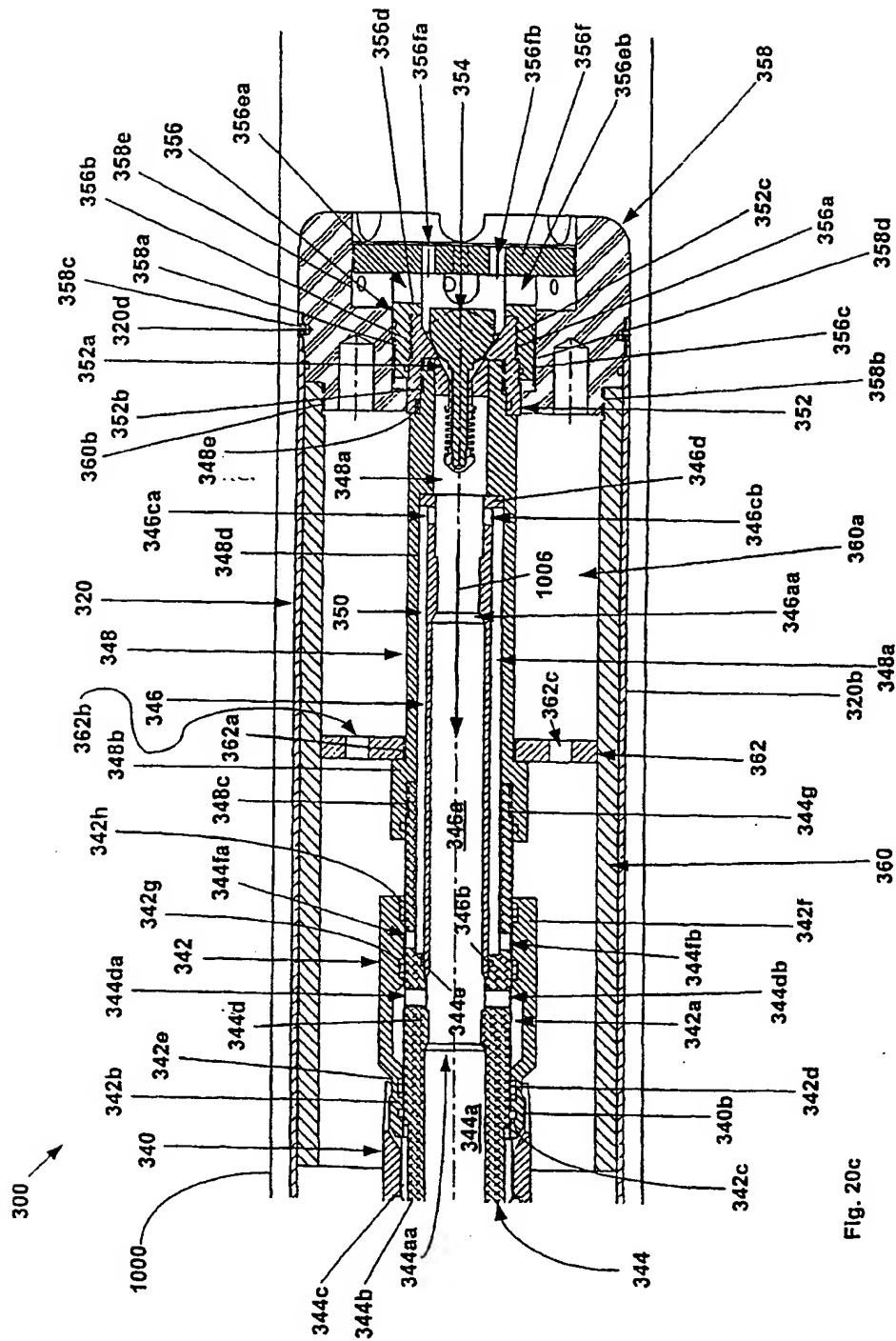
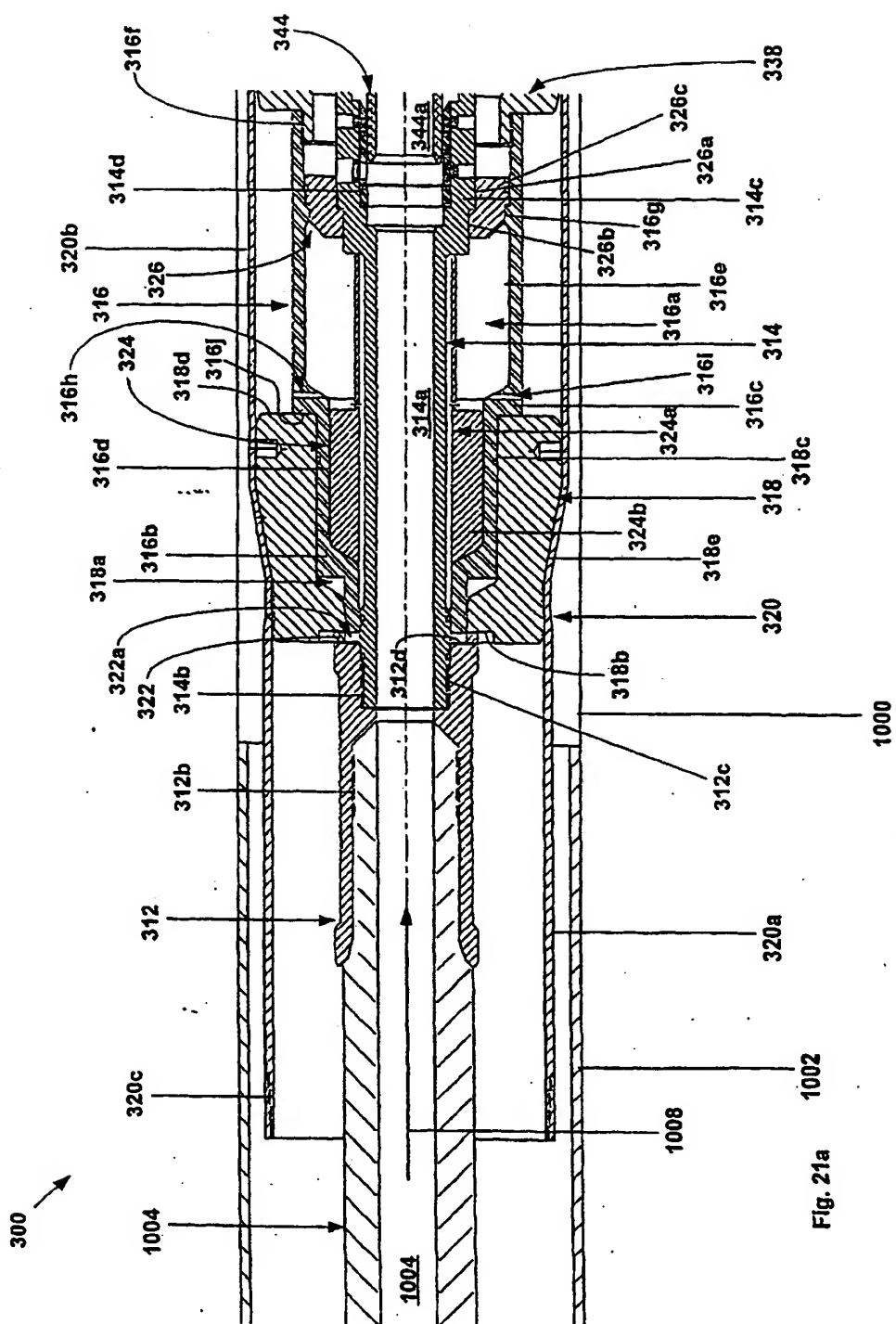
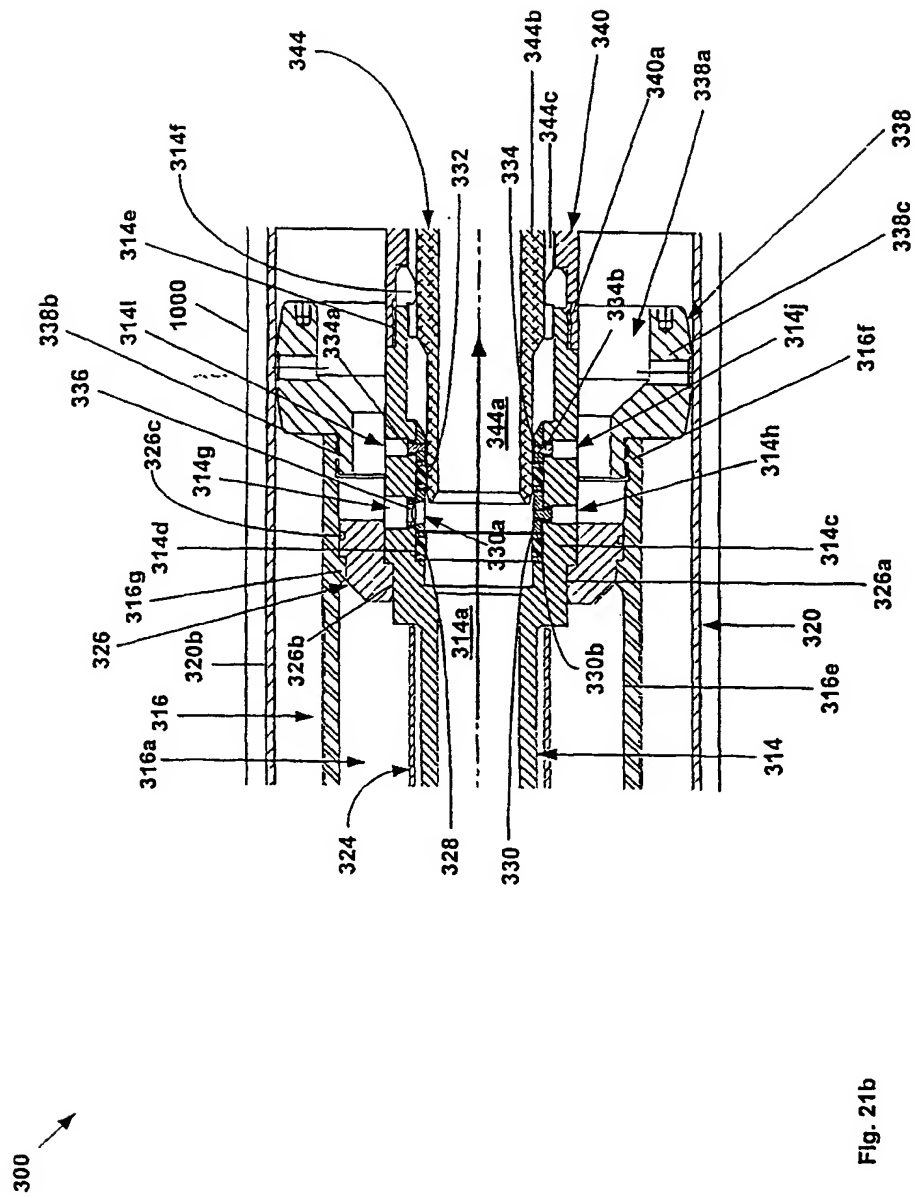


Fig. 20c



**Fig. 21a**



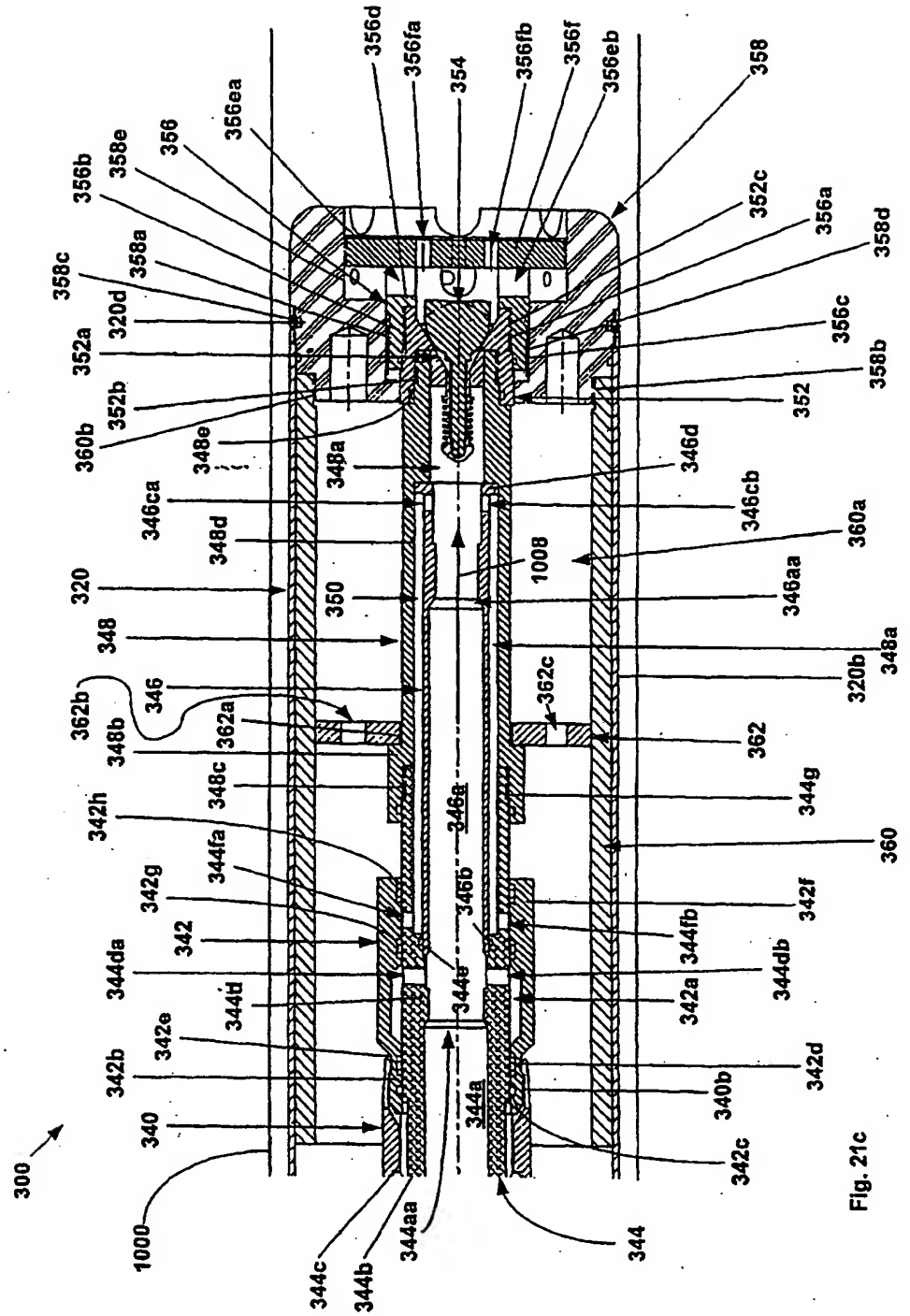


Fig. 21c

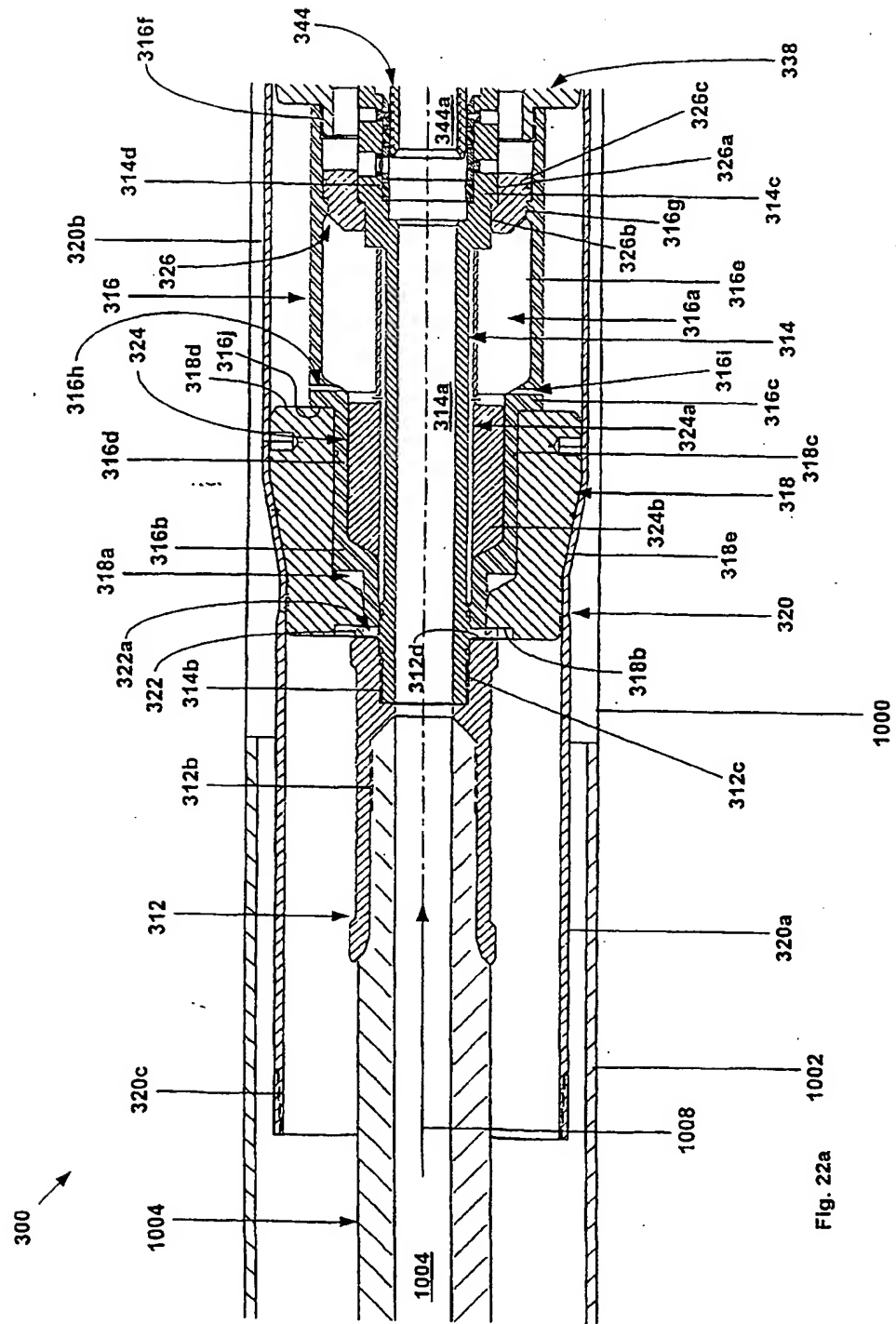


Fig. 22a

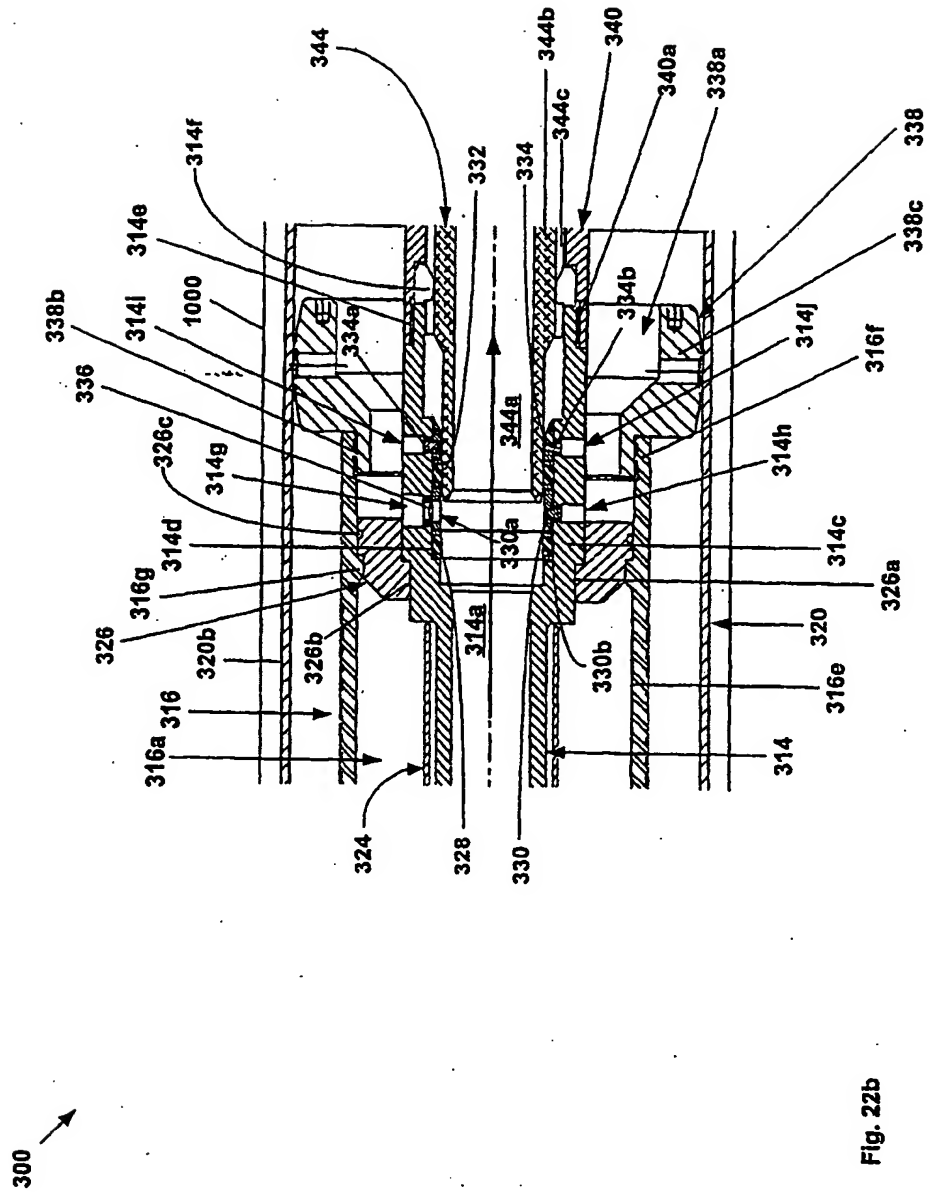


Fig. 22b

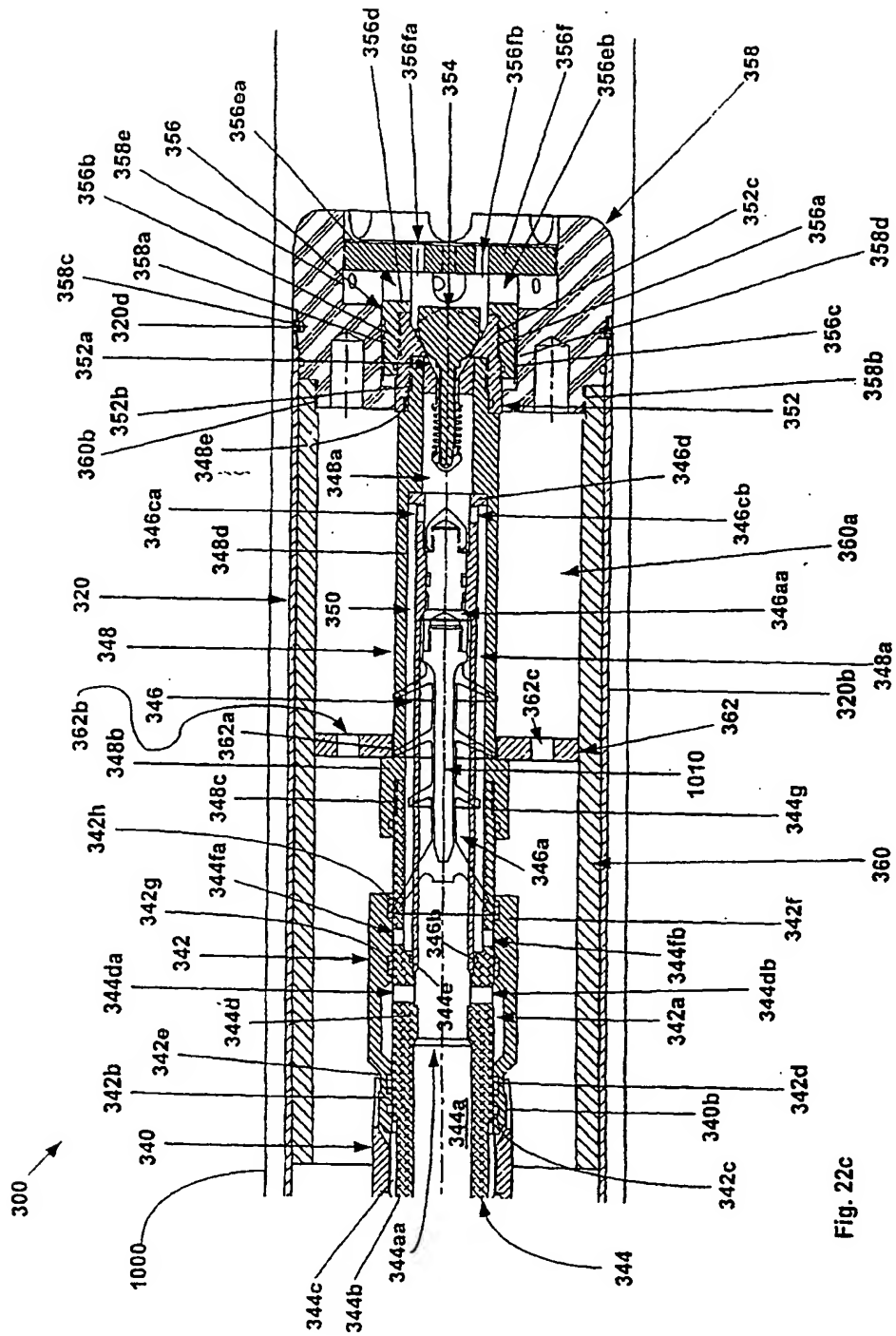
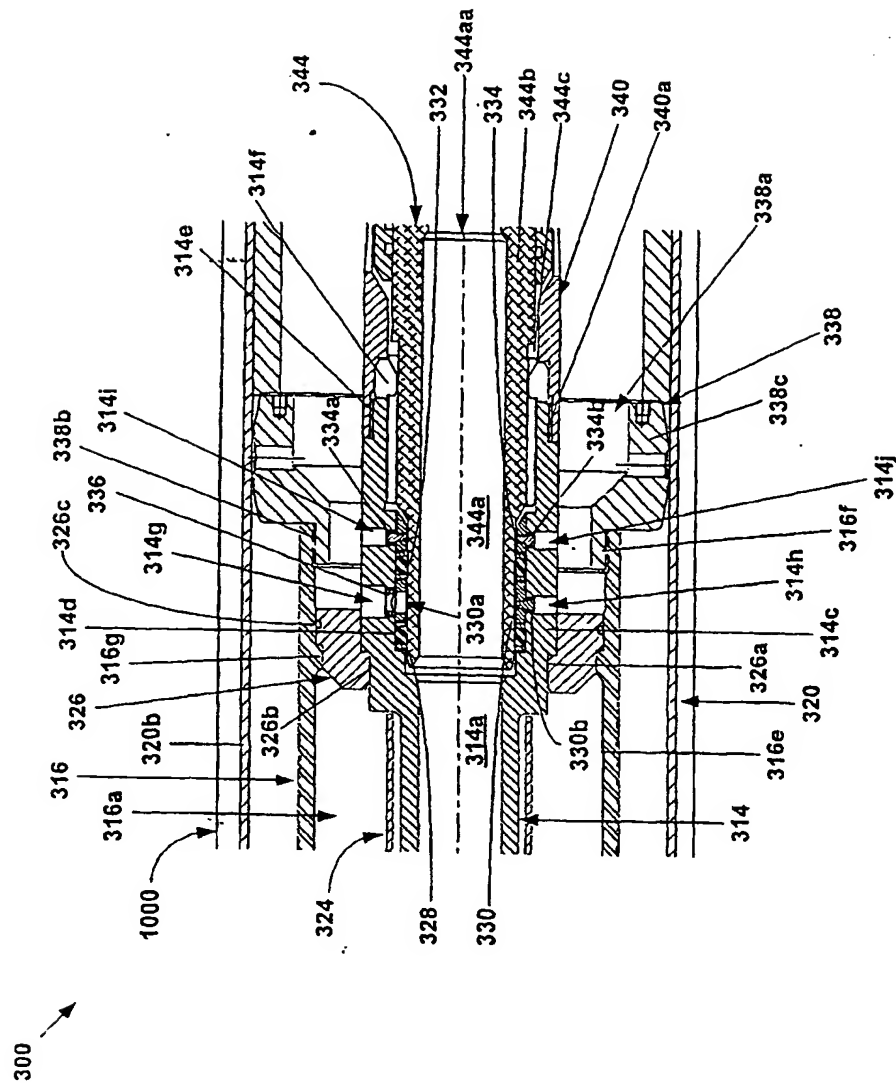


Fig. 22c







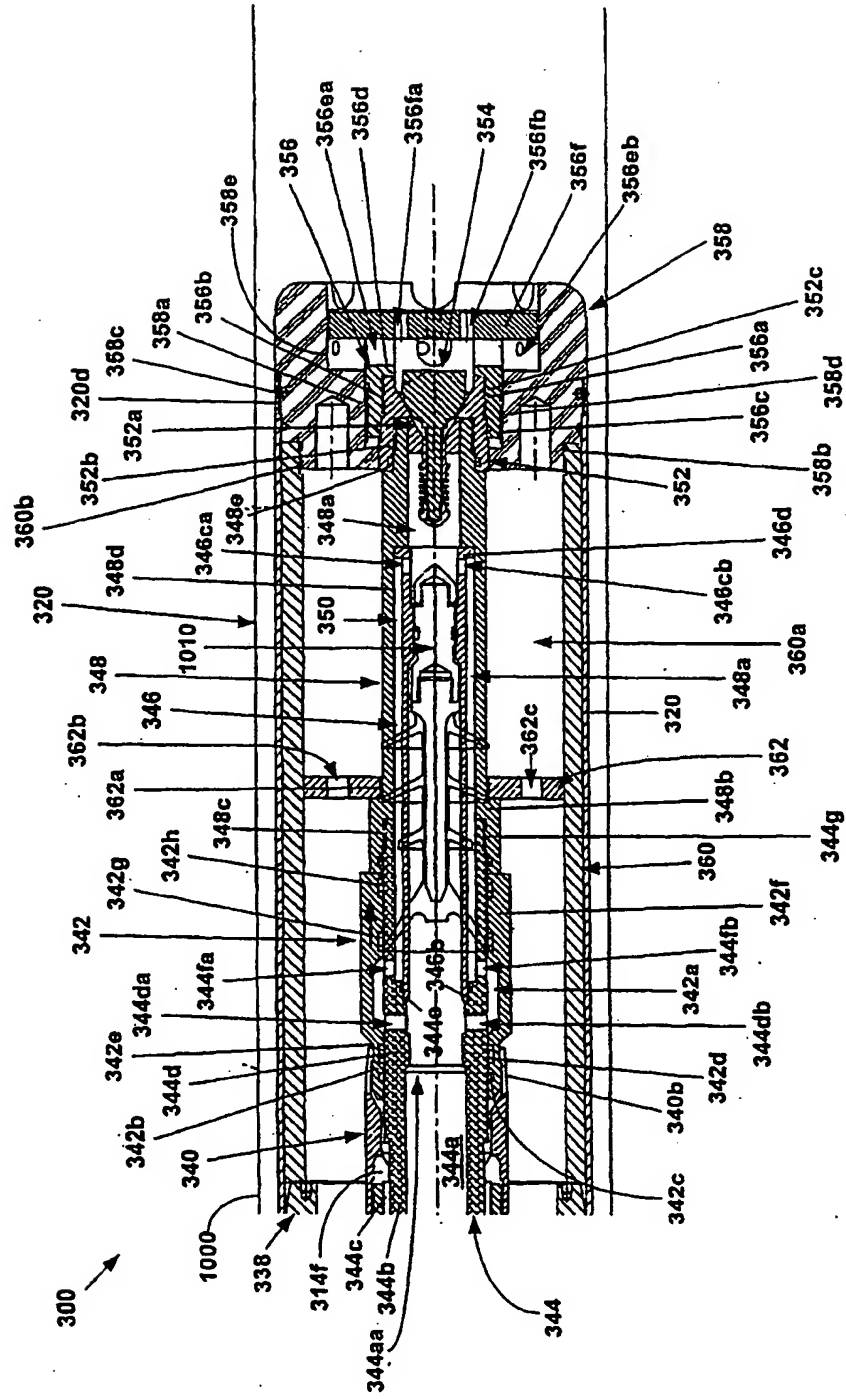


Fig. 23c

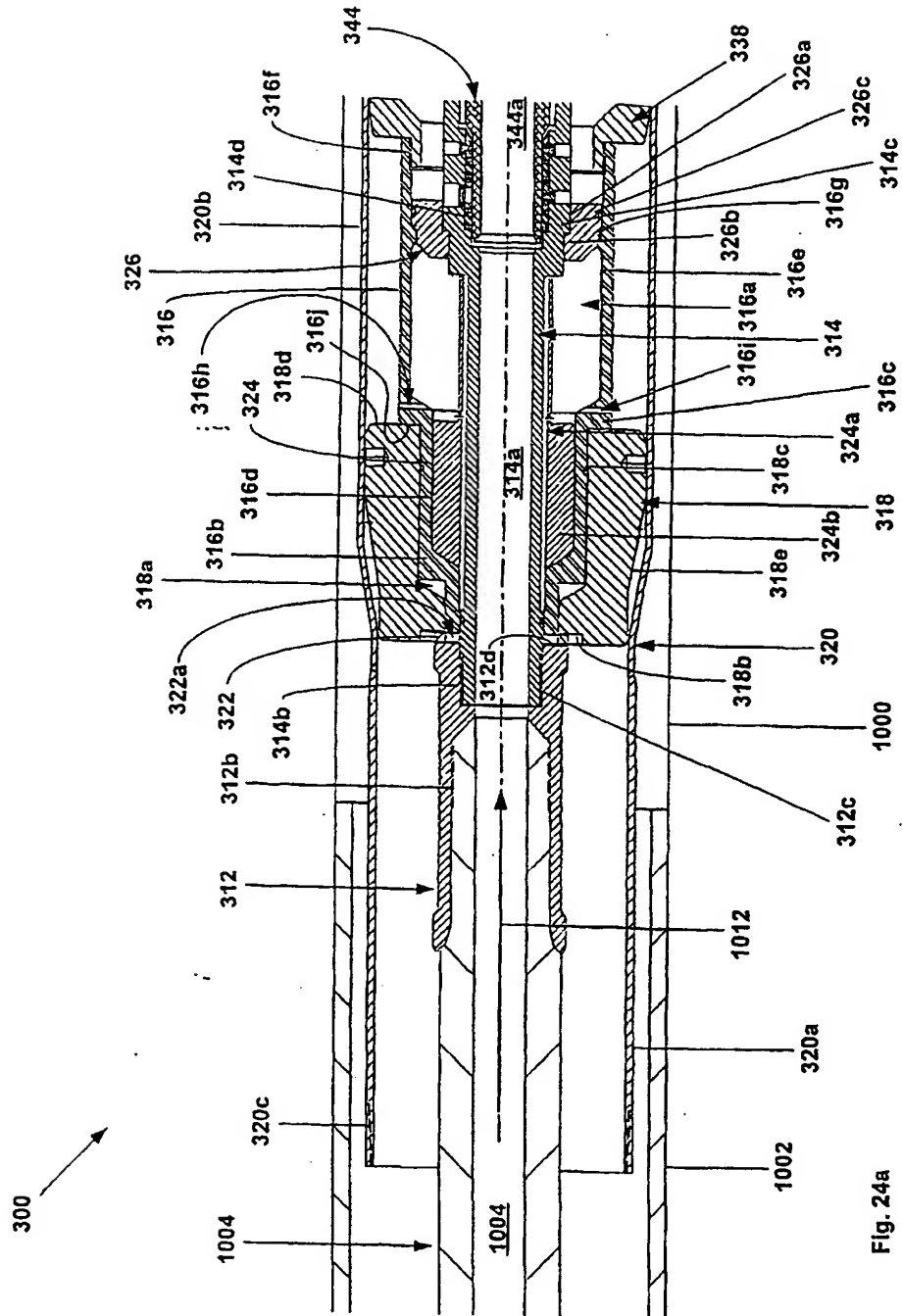
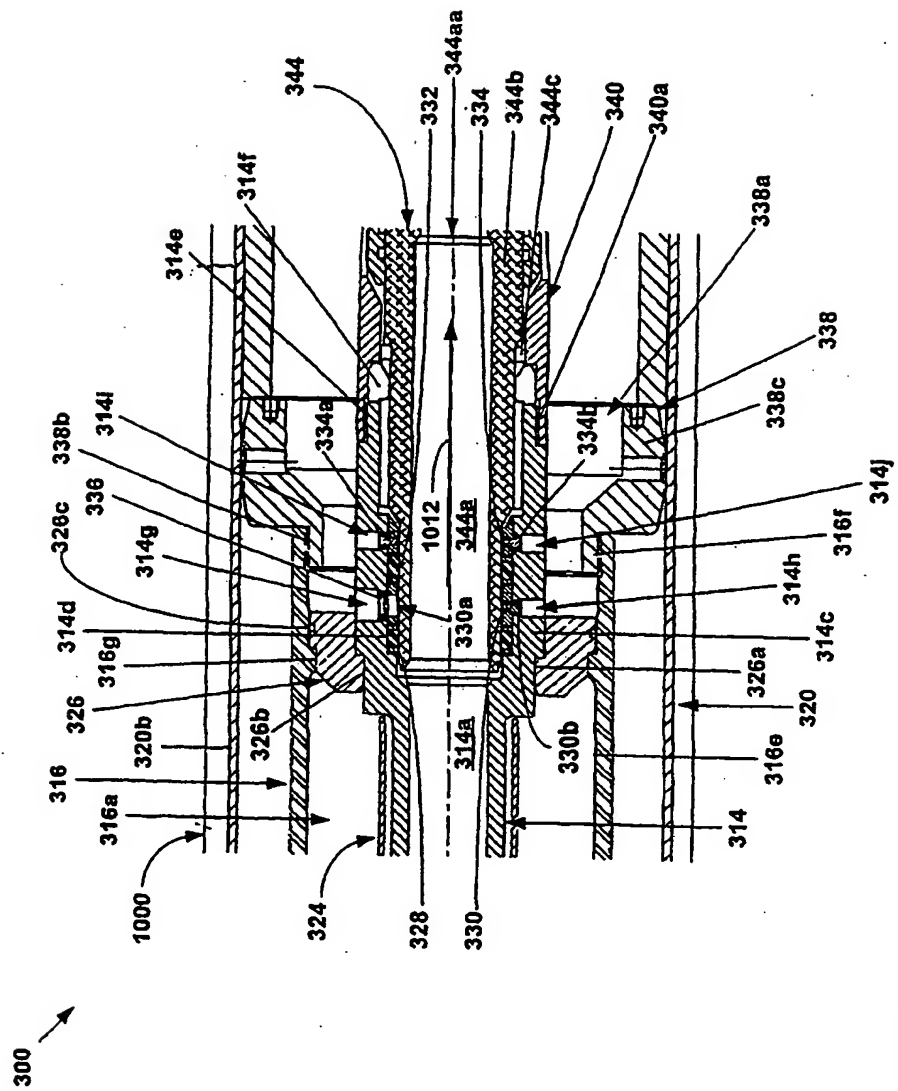


Fig. 24a



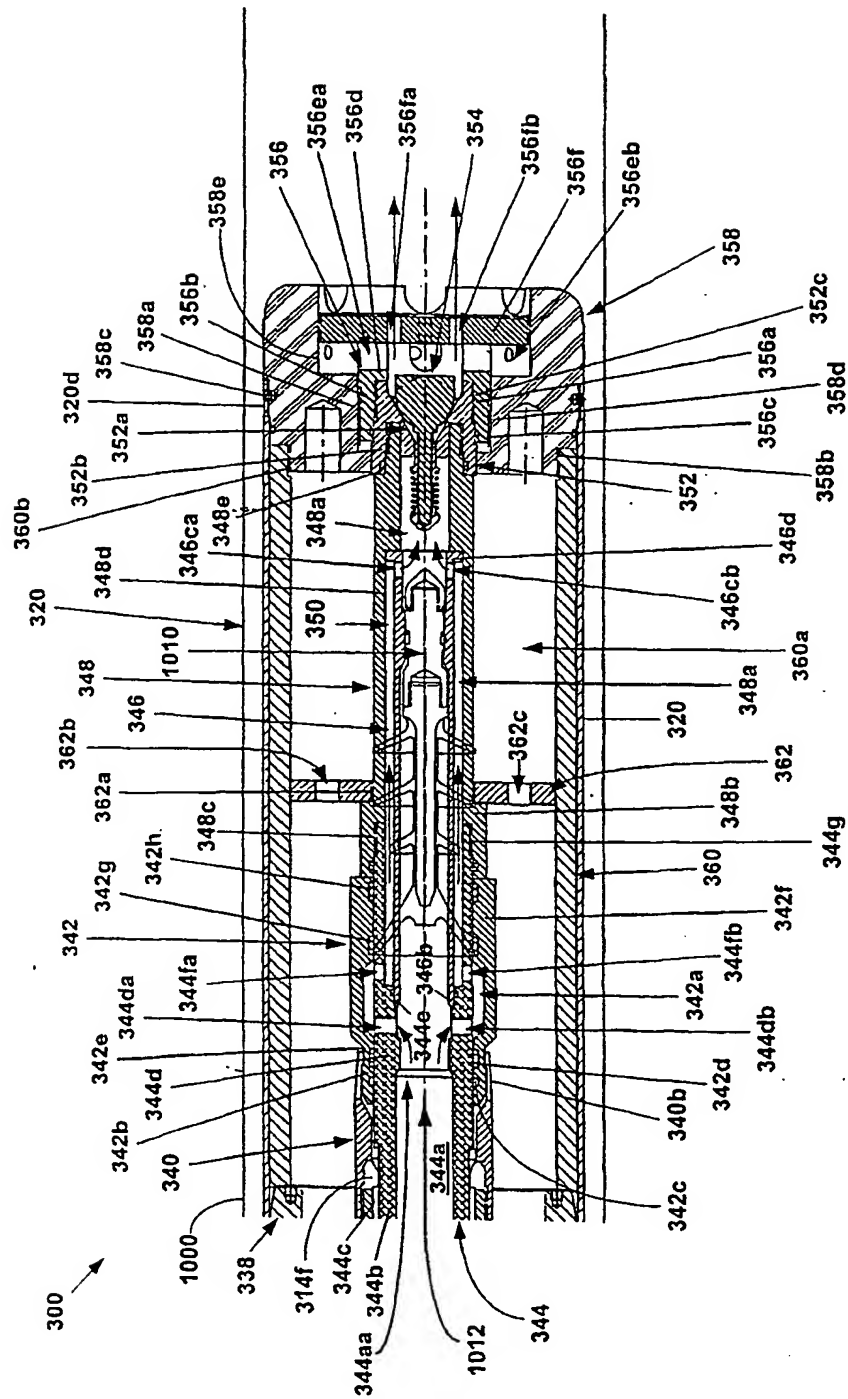


Fig. 24c

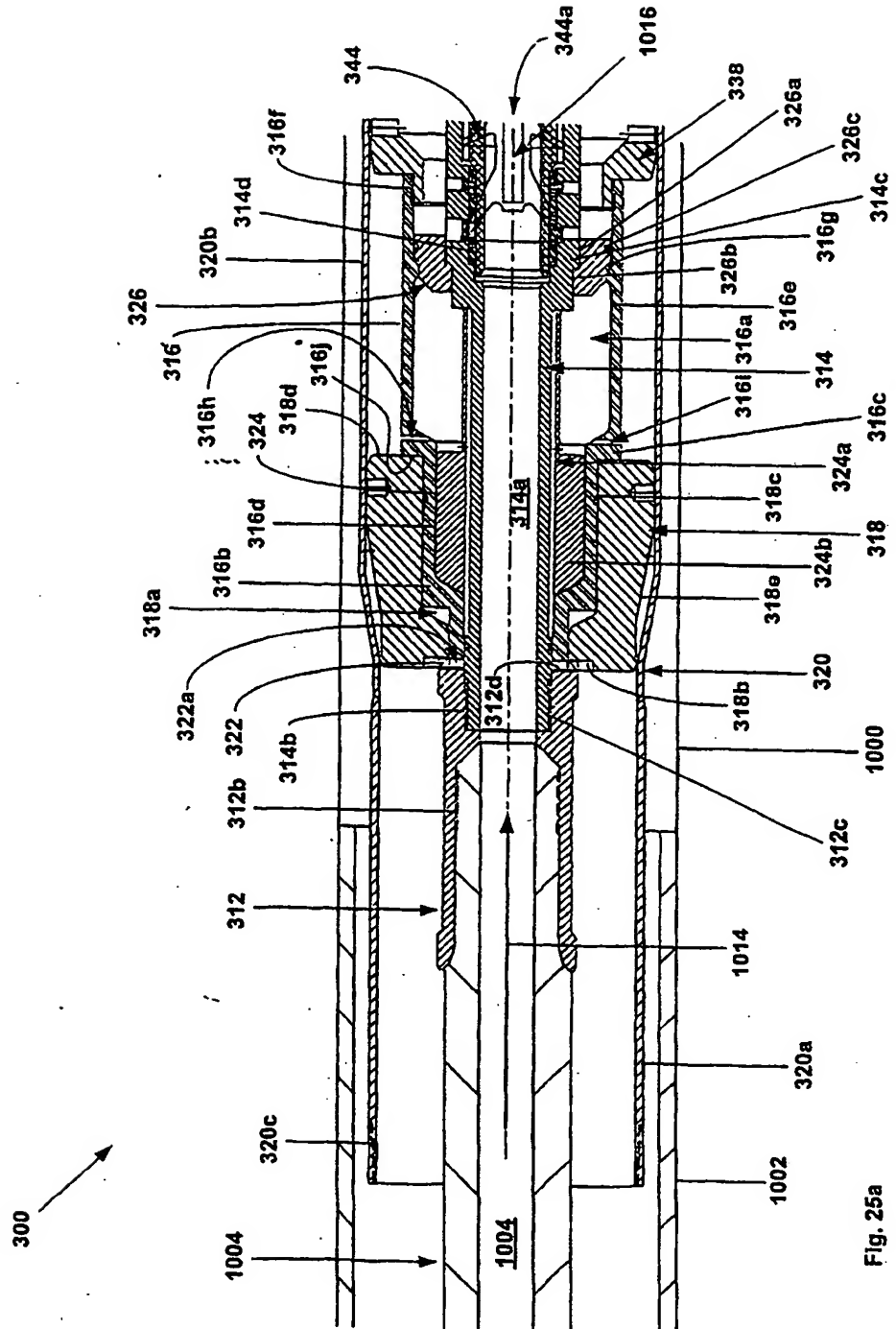


Fig. 25a

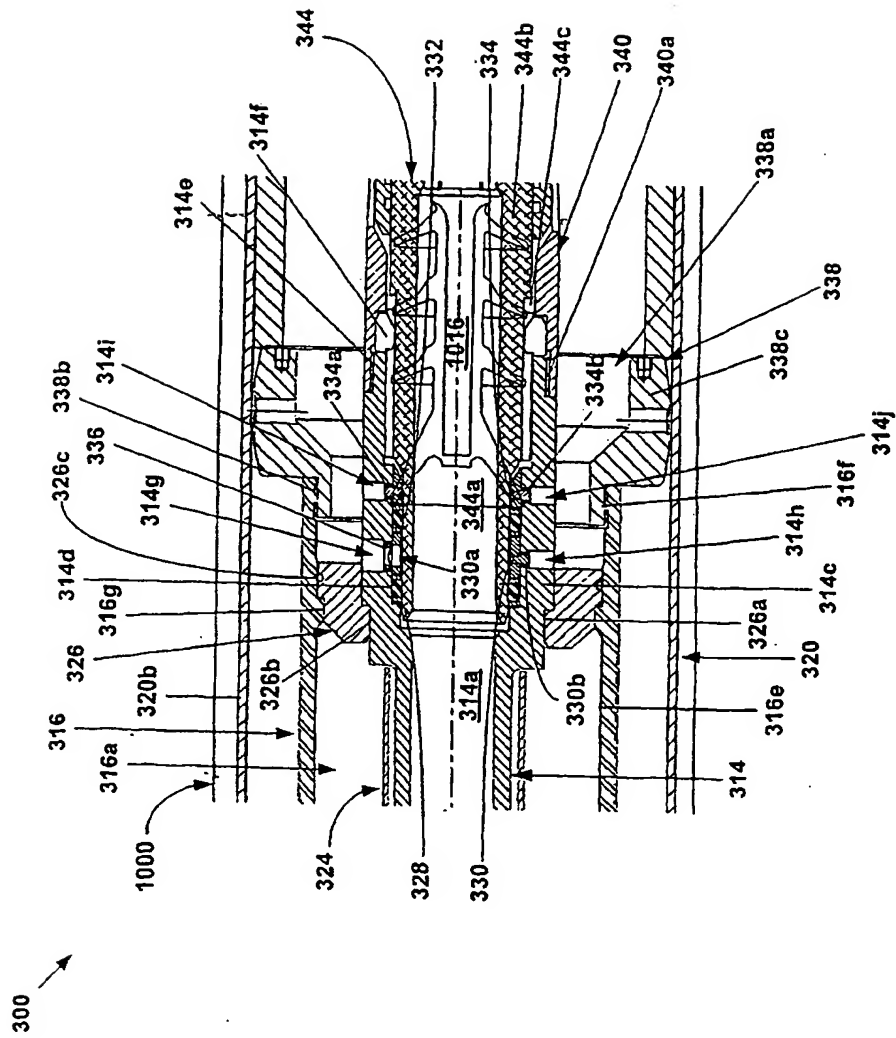


Fig. 25b

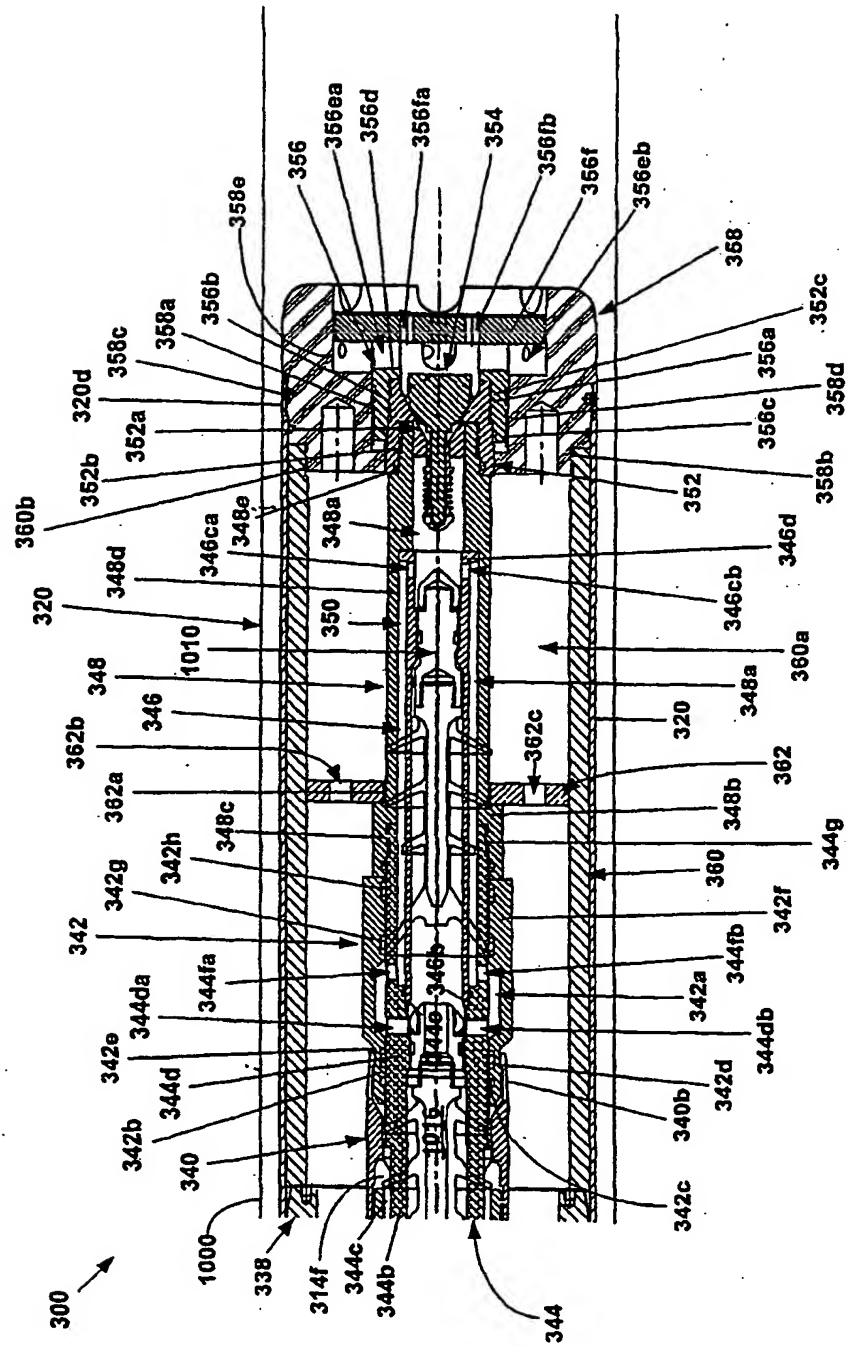
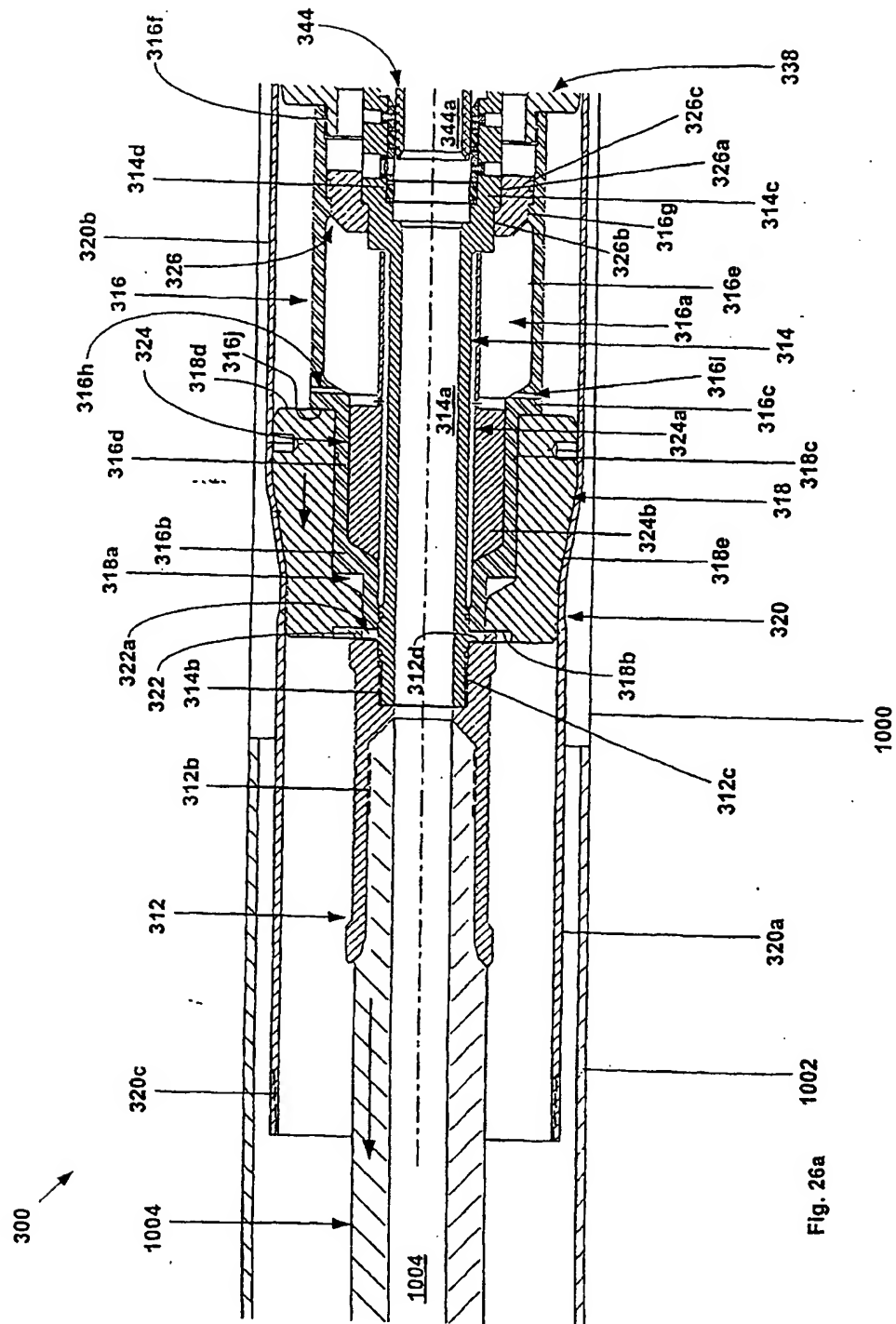
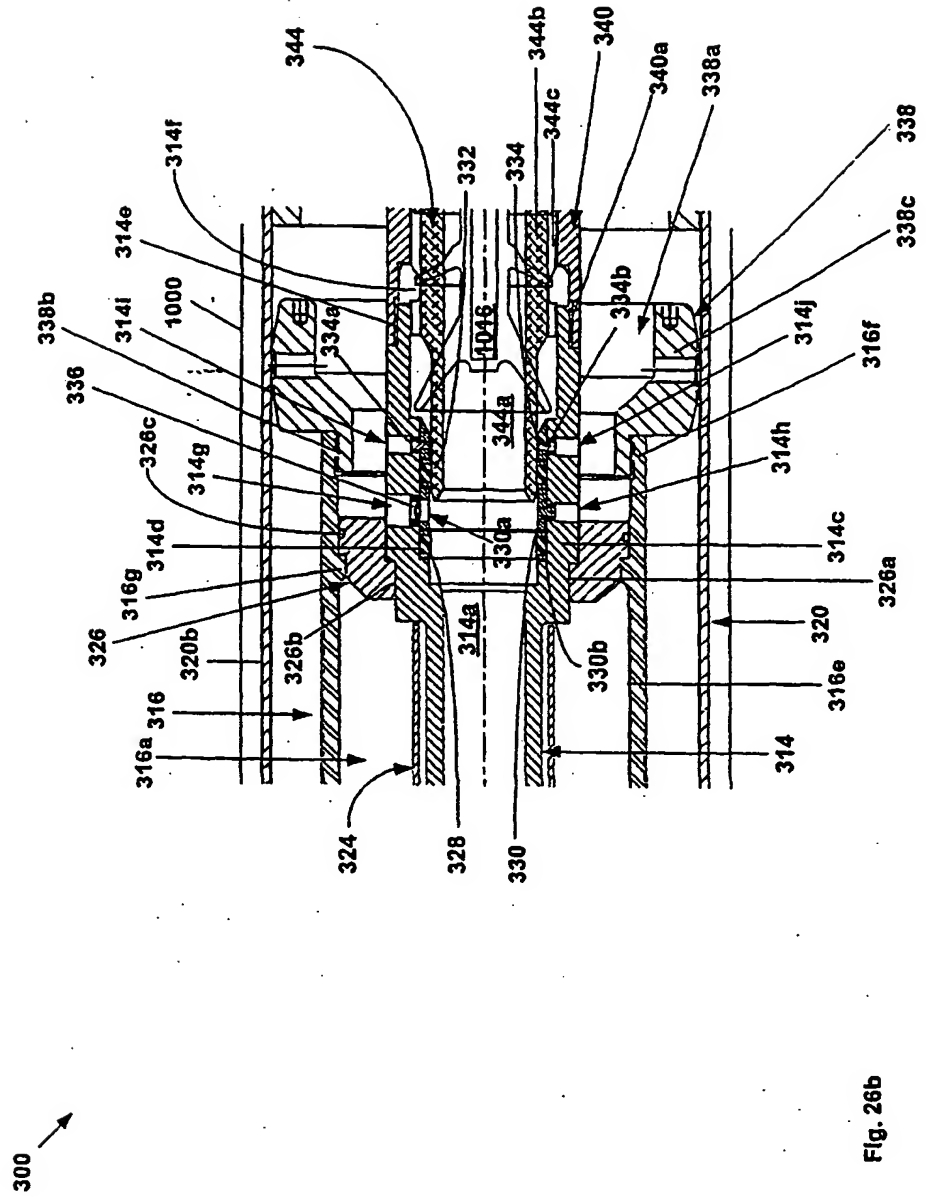


Fig. 25c







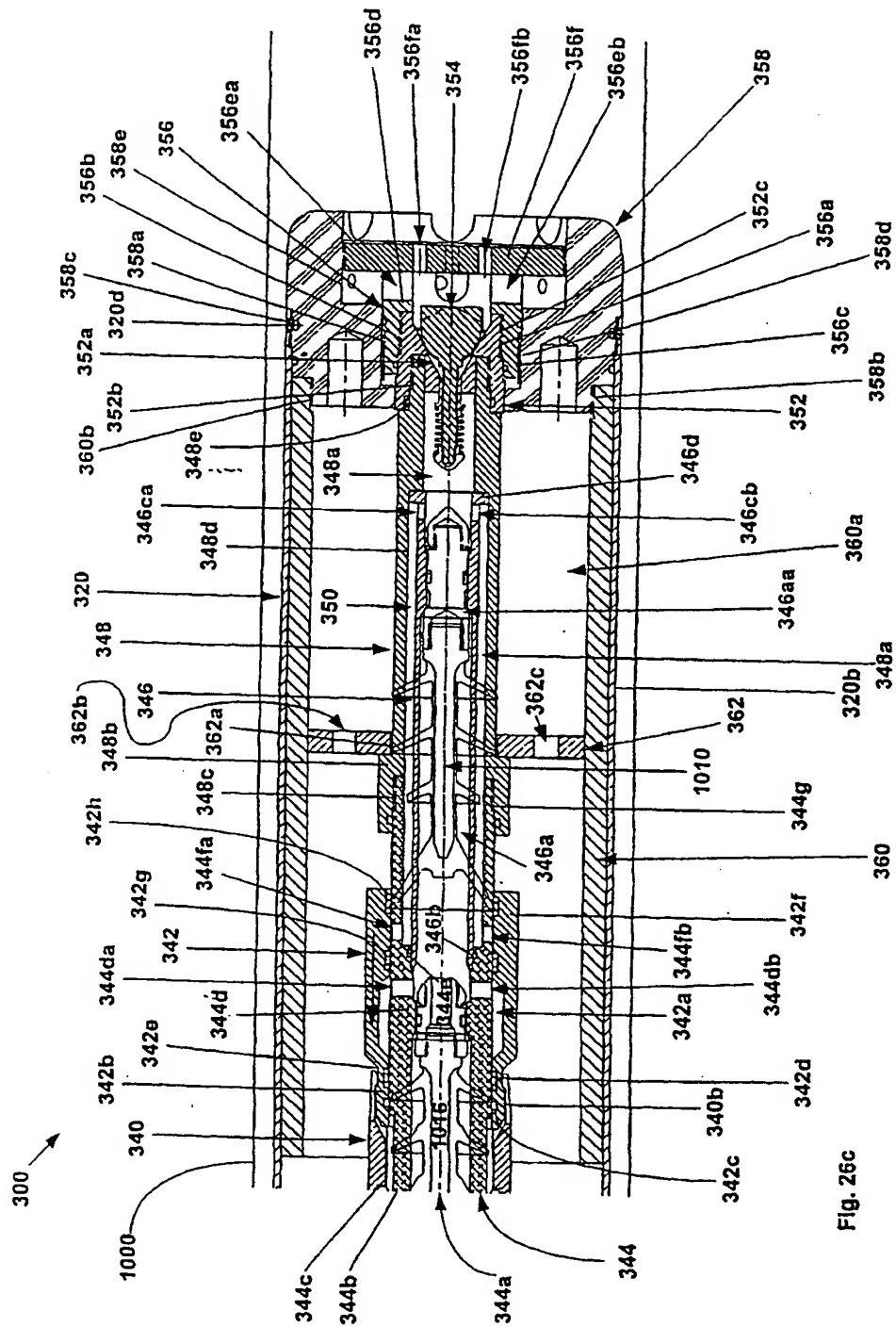


Fig. 26c

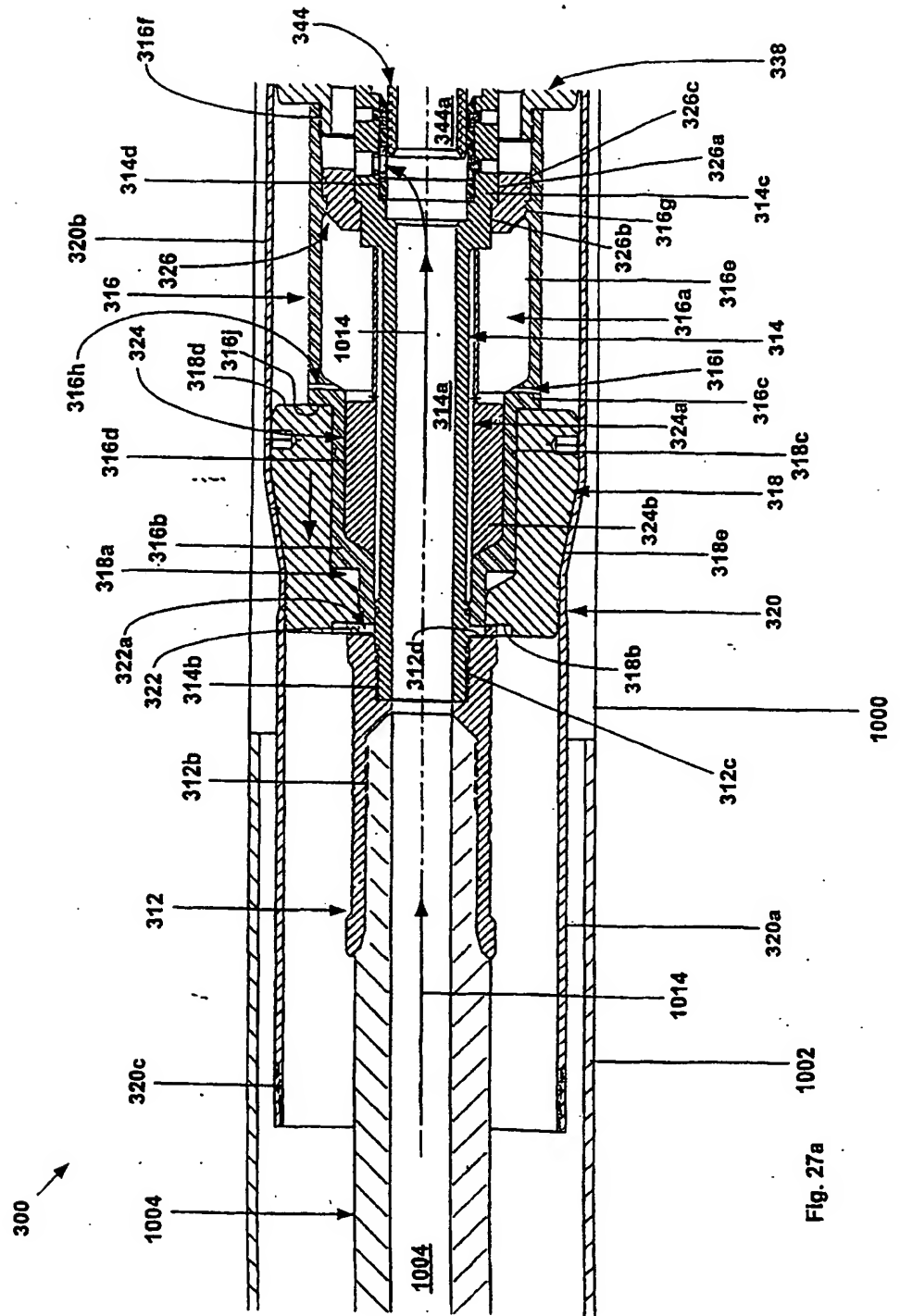
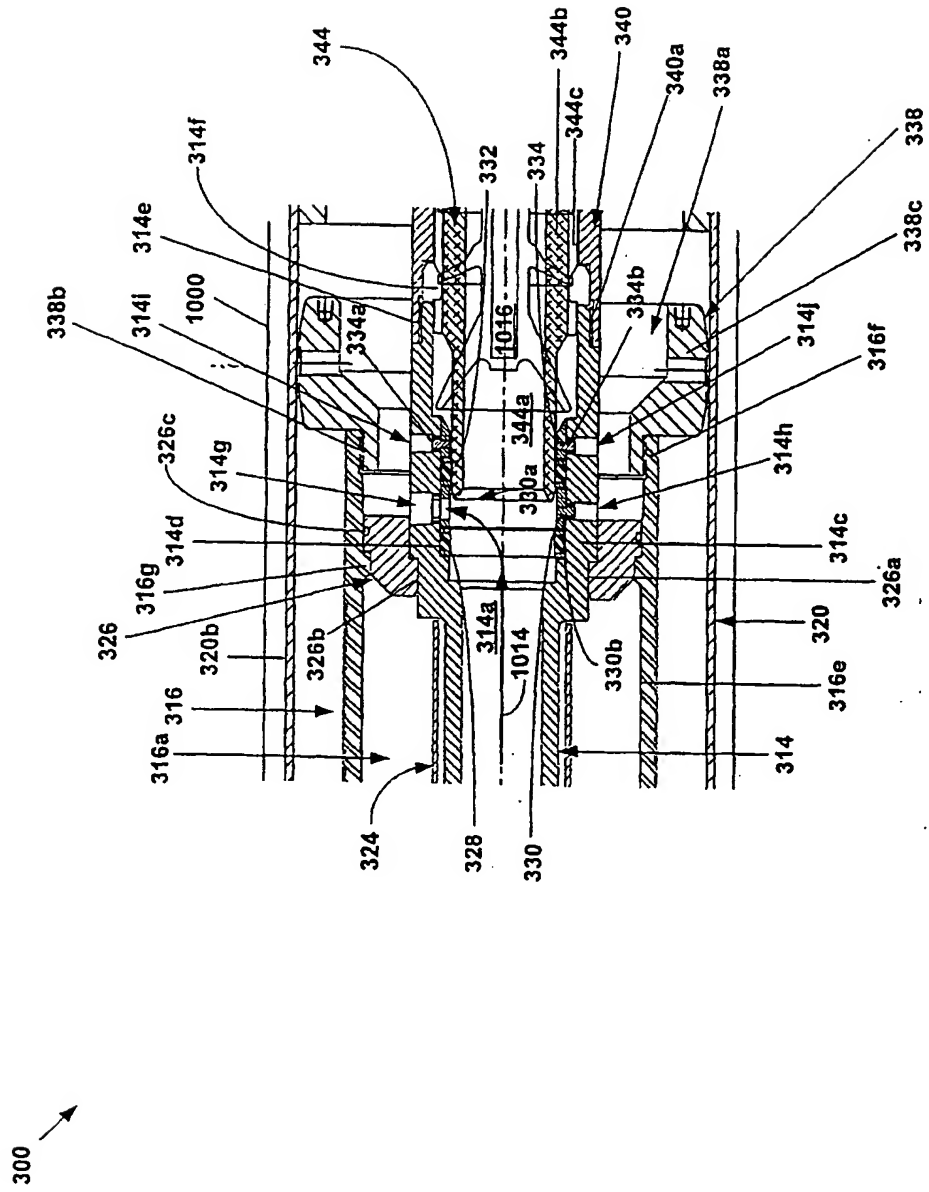
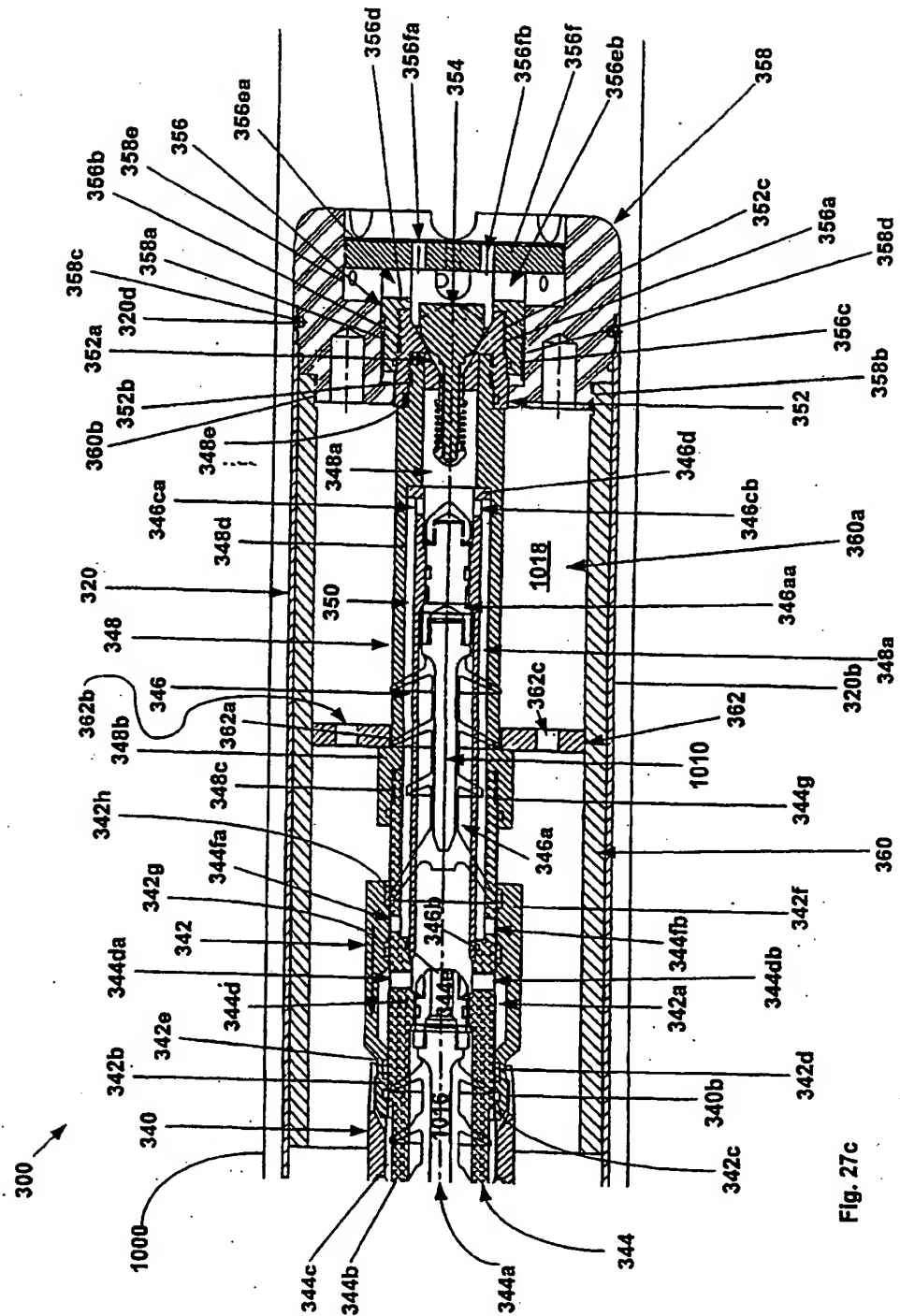


Fig. 27a





450

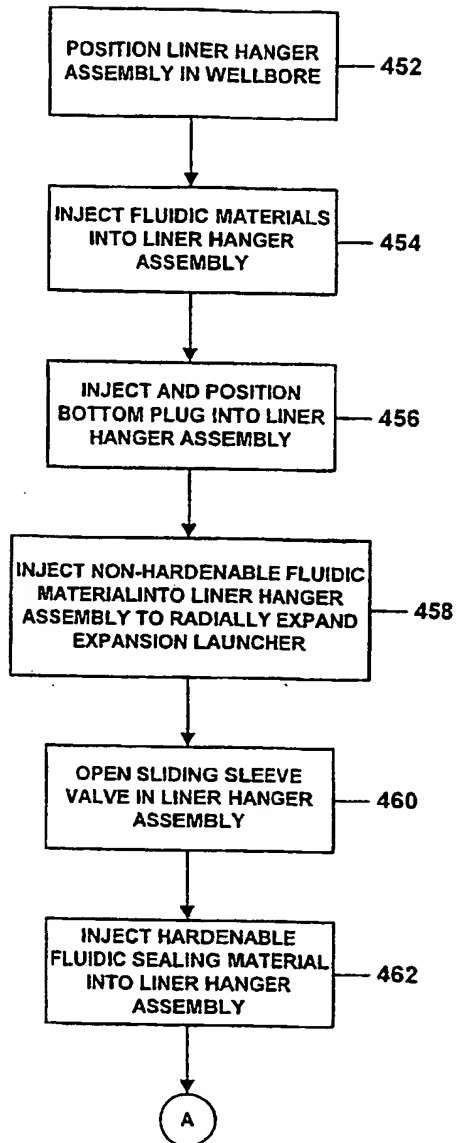


Fig. 28a

450

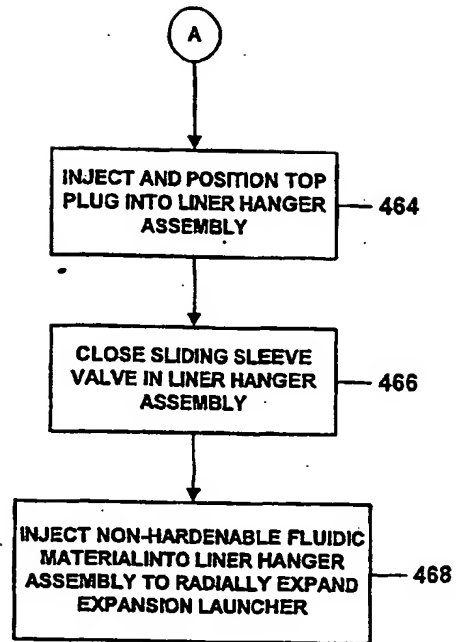
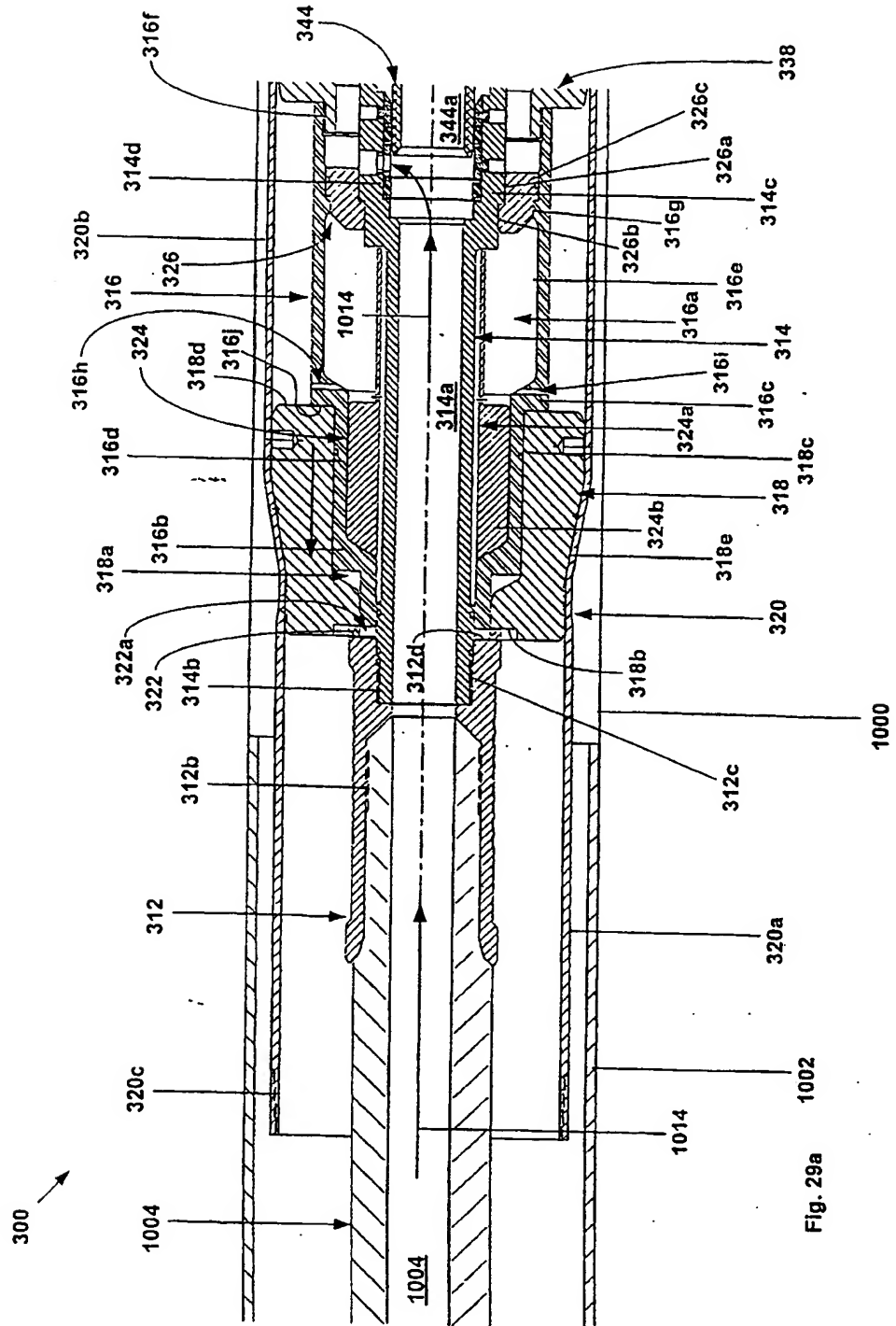


Fig. 28b





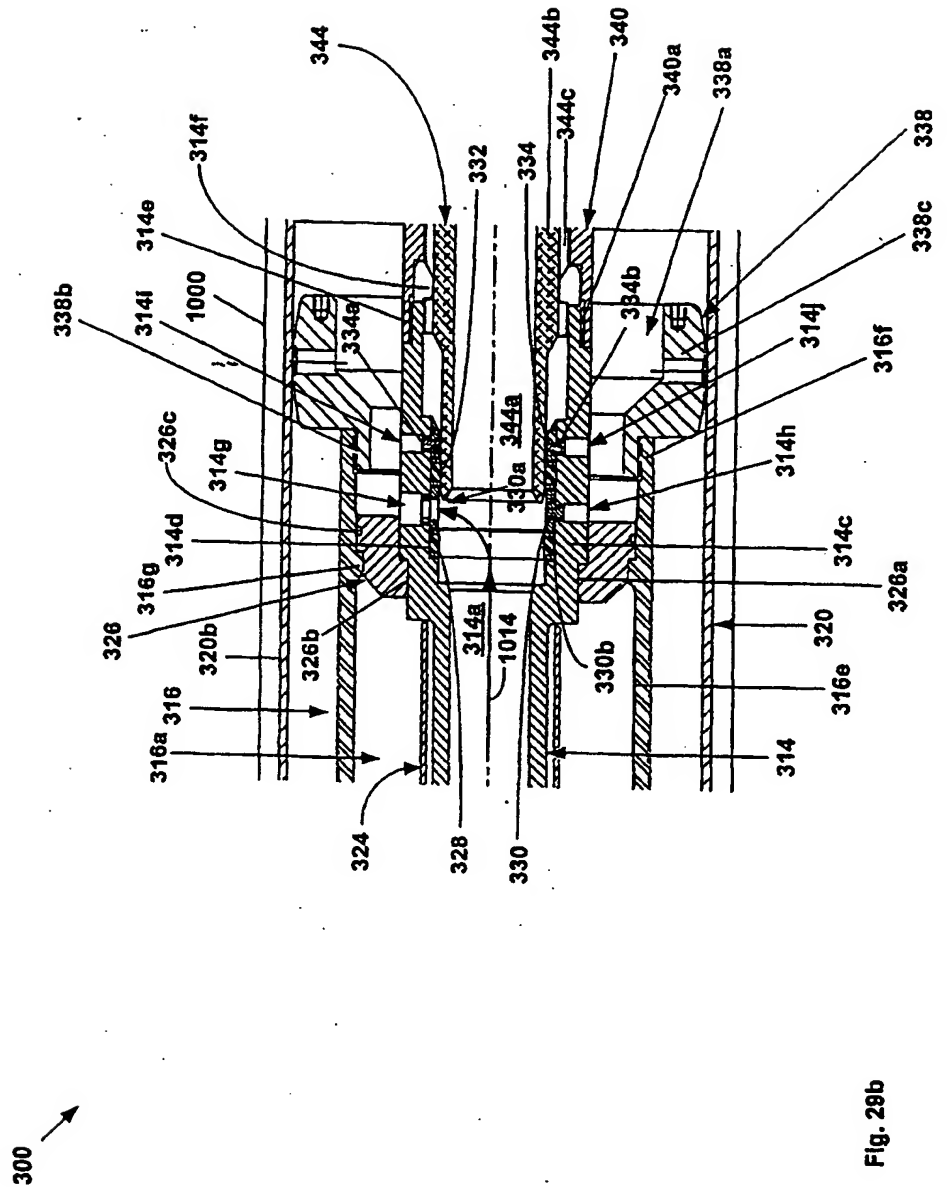


Fig. 29b

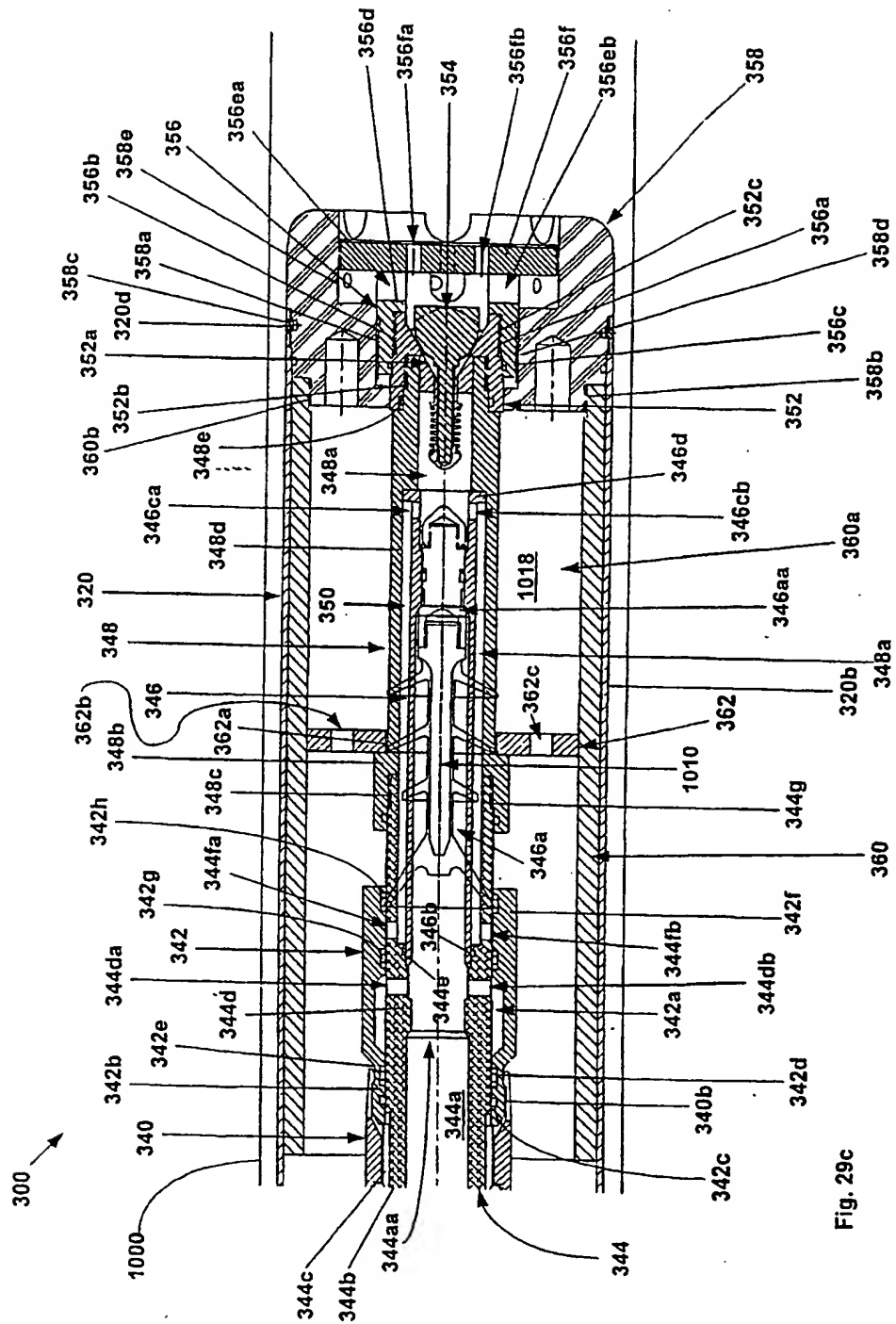
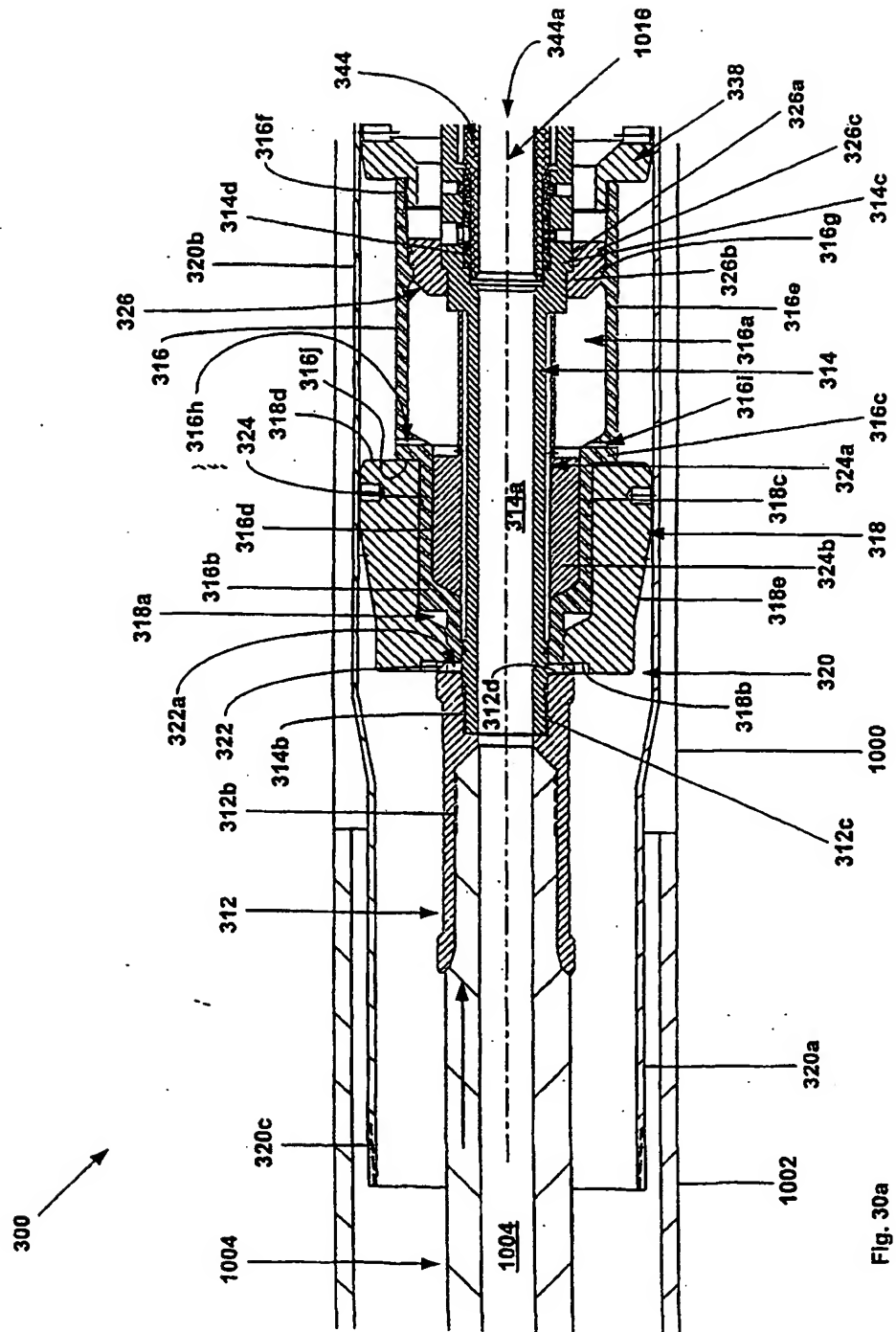


Fig. 29c



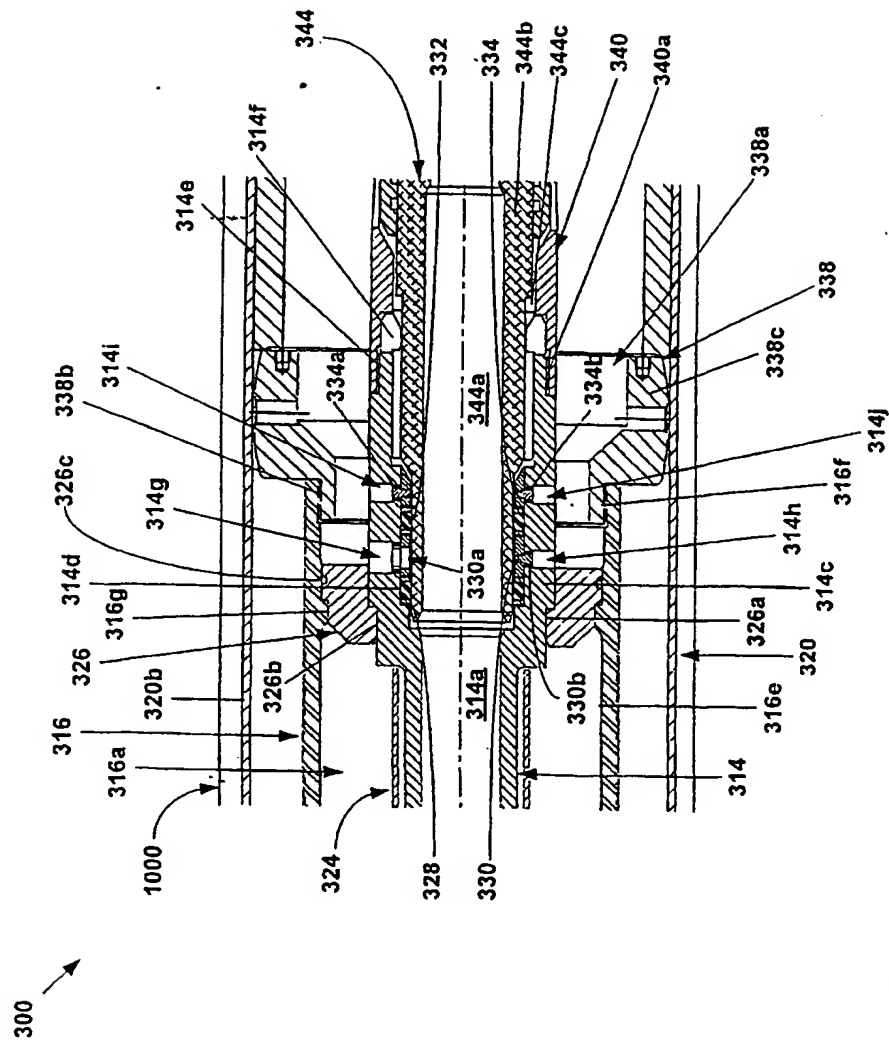


Fig. 30b

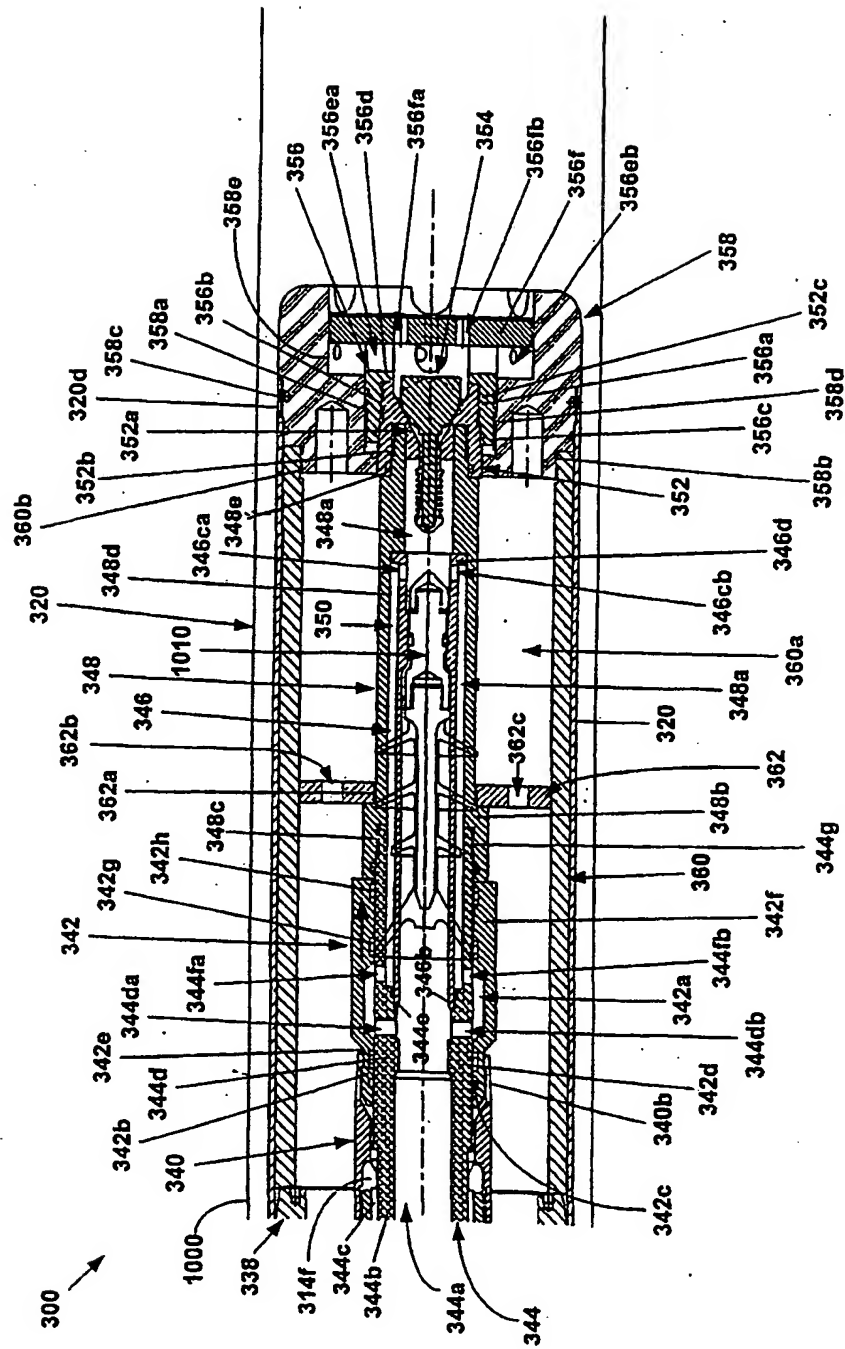


Fig. 30c

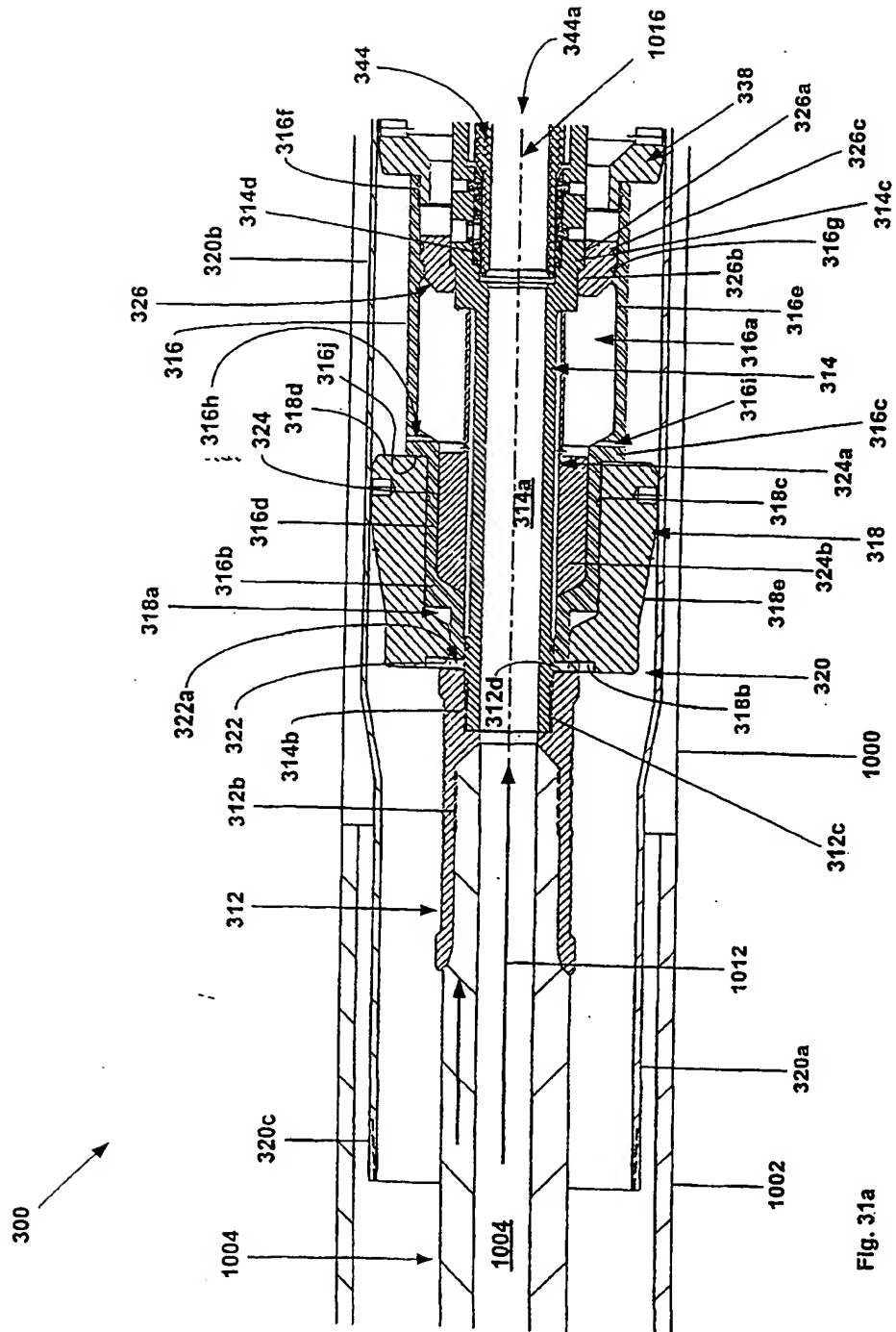


Fig. 31a

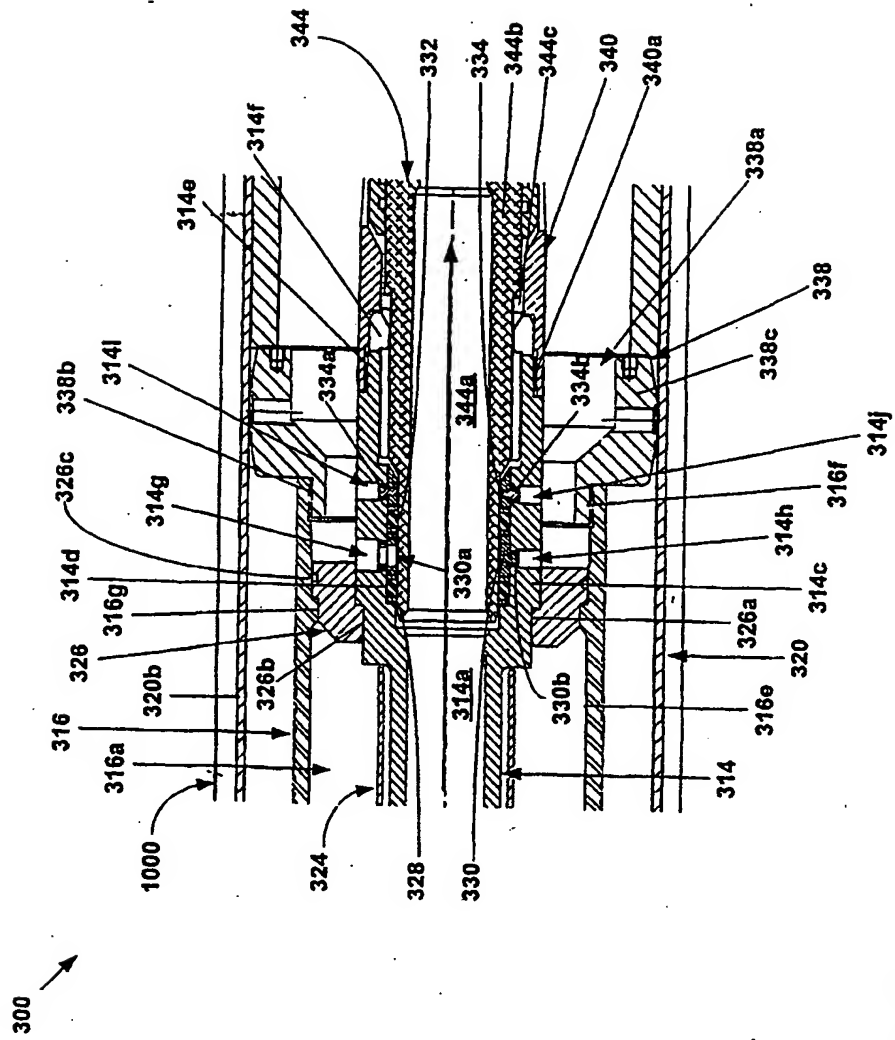


Fig. 31b



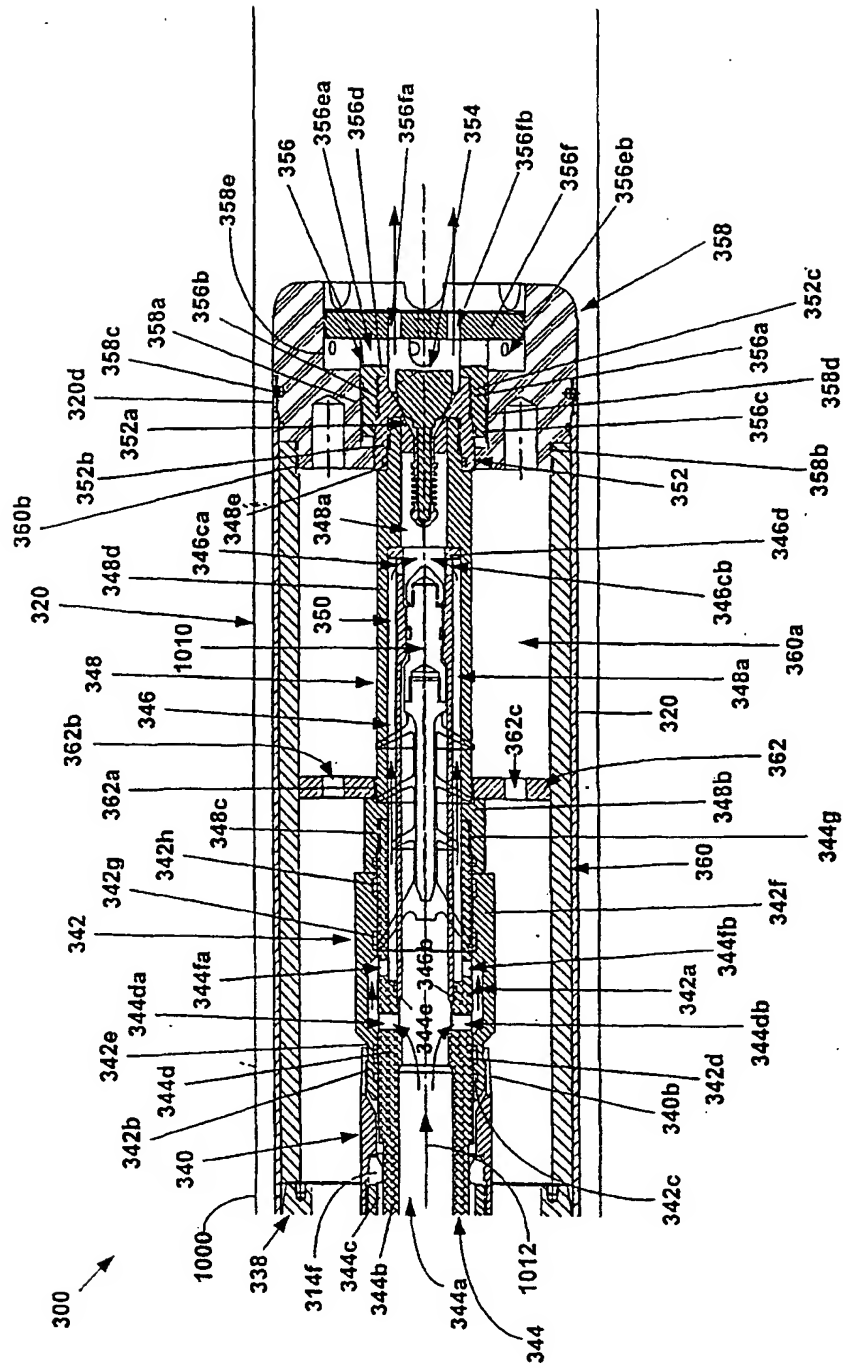
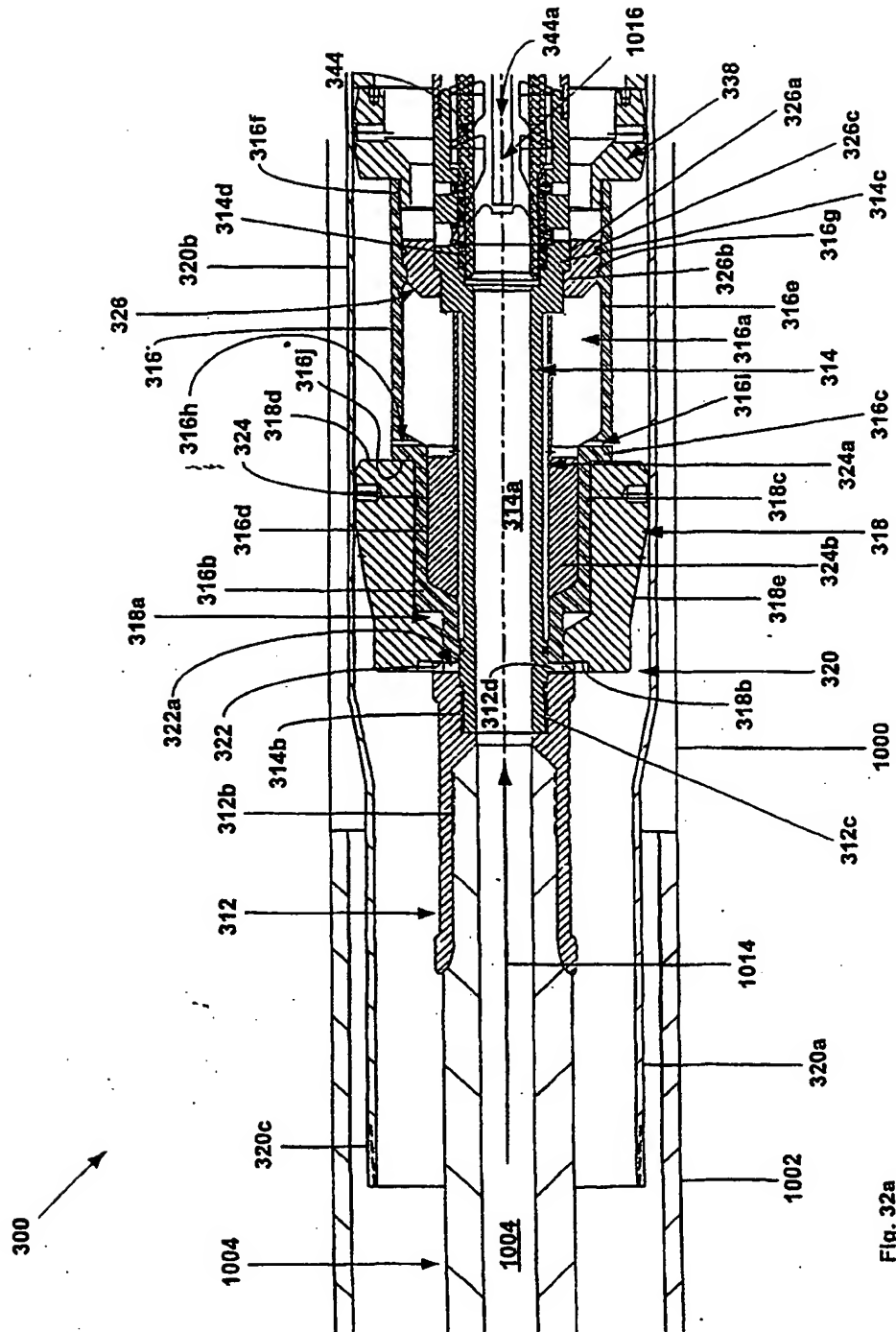
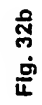
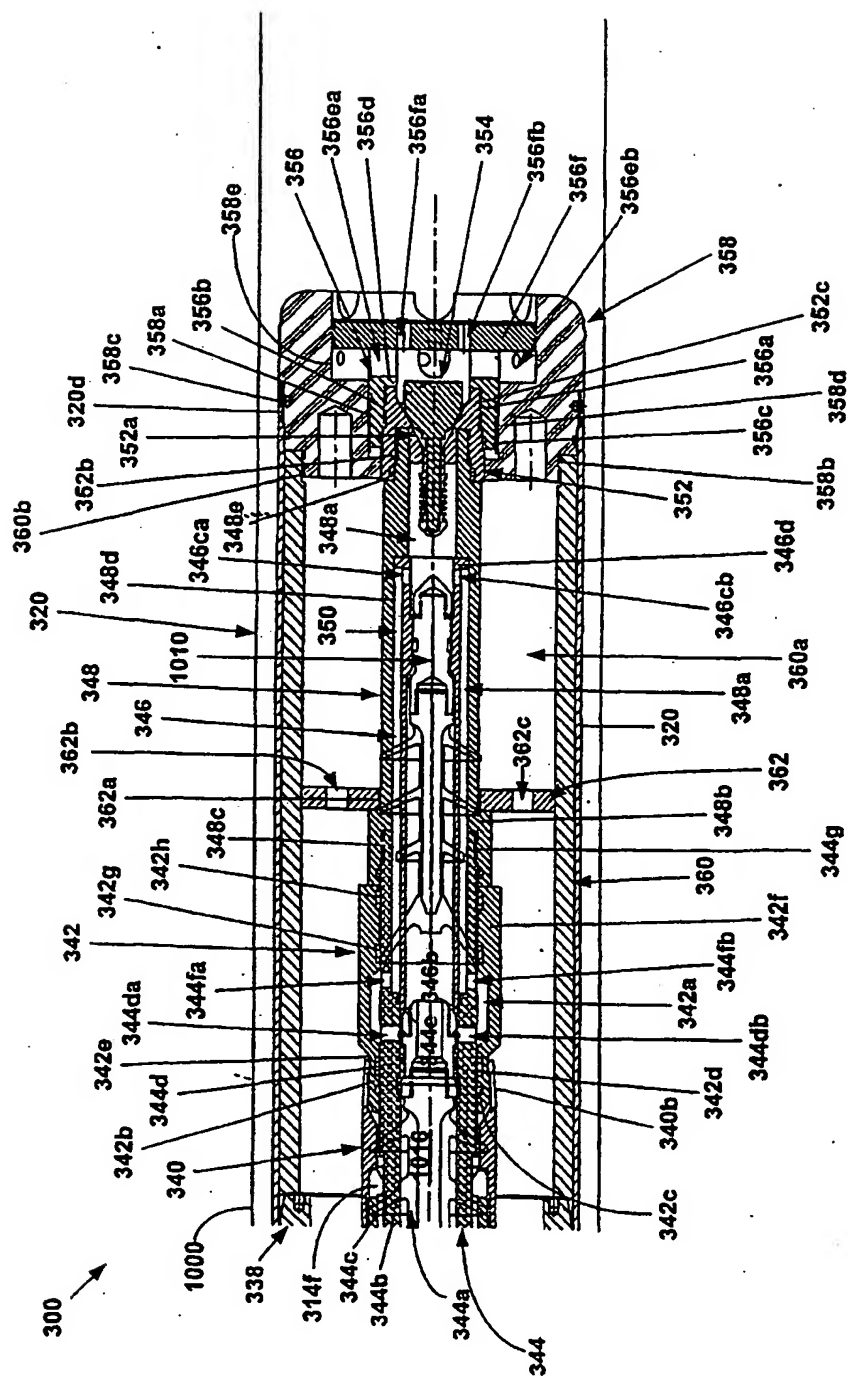


Fig. 31c







**Fig. 32c**

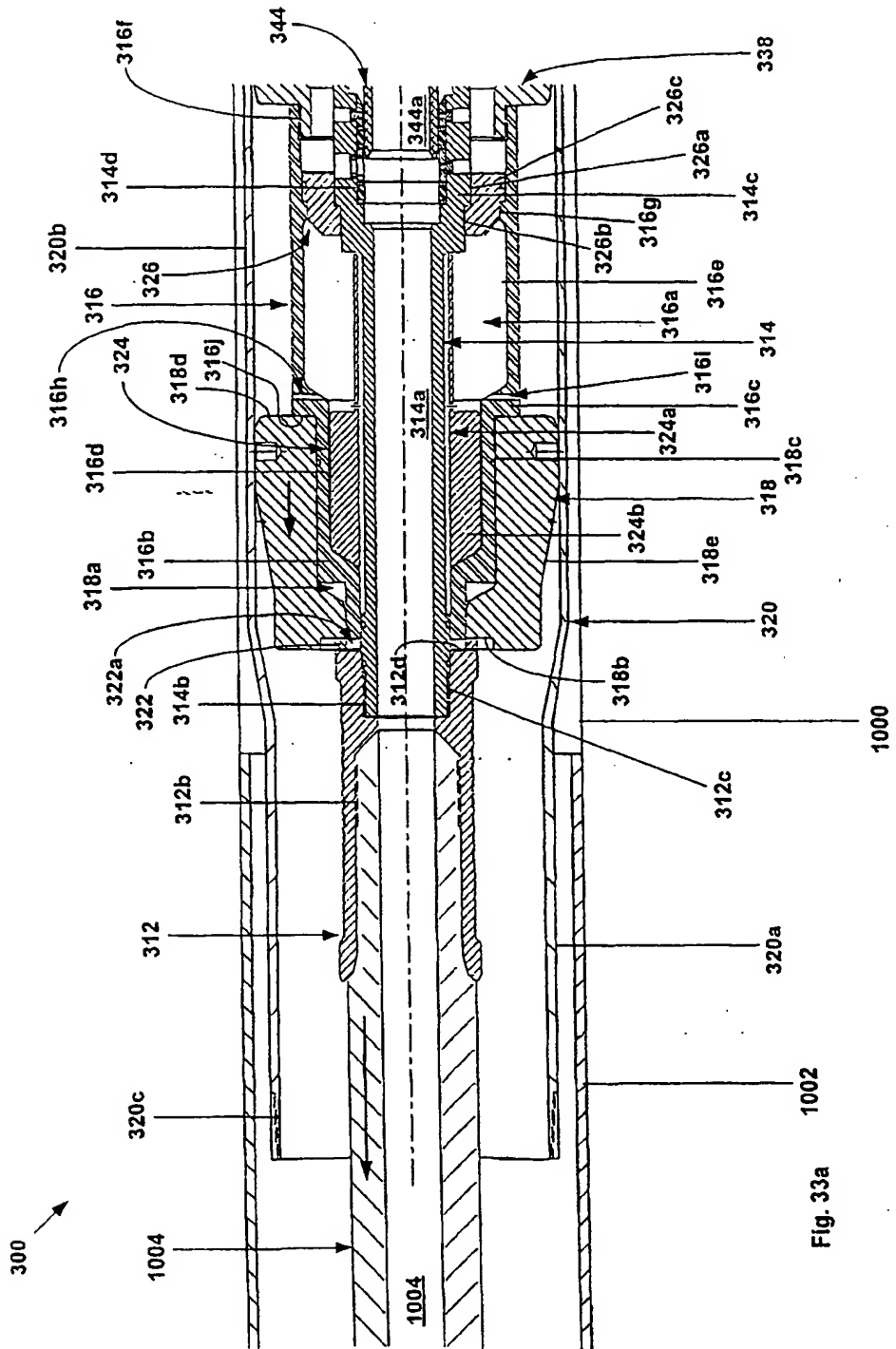
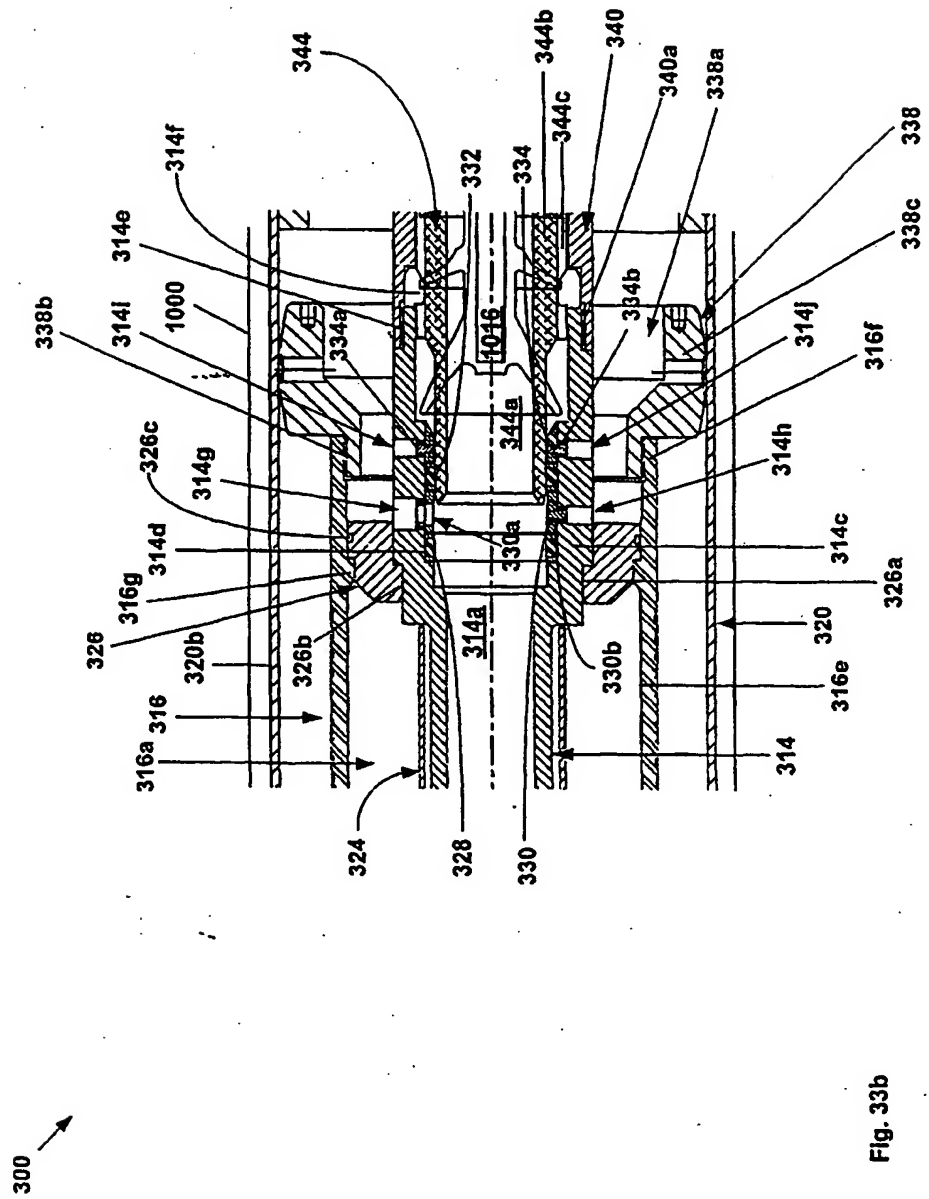


Fig. 33a



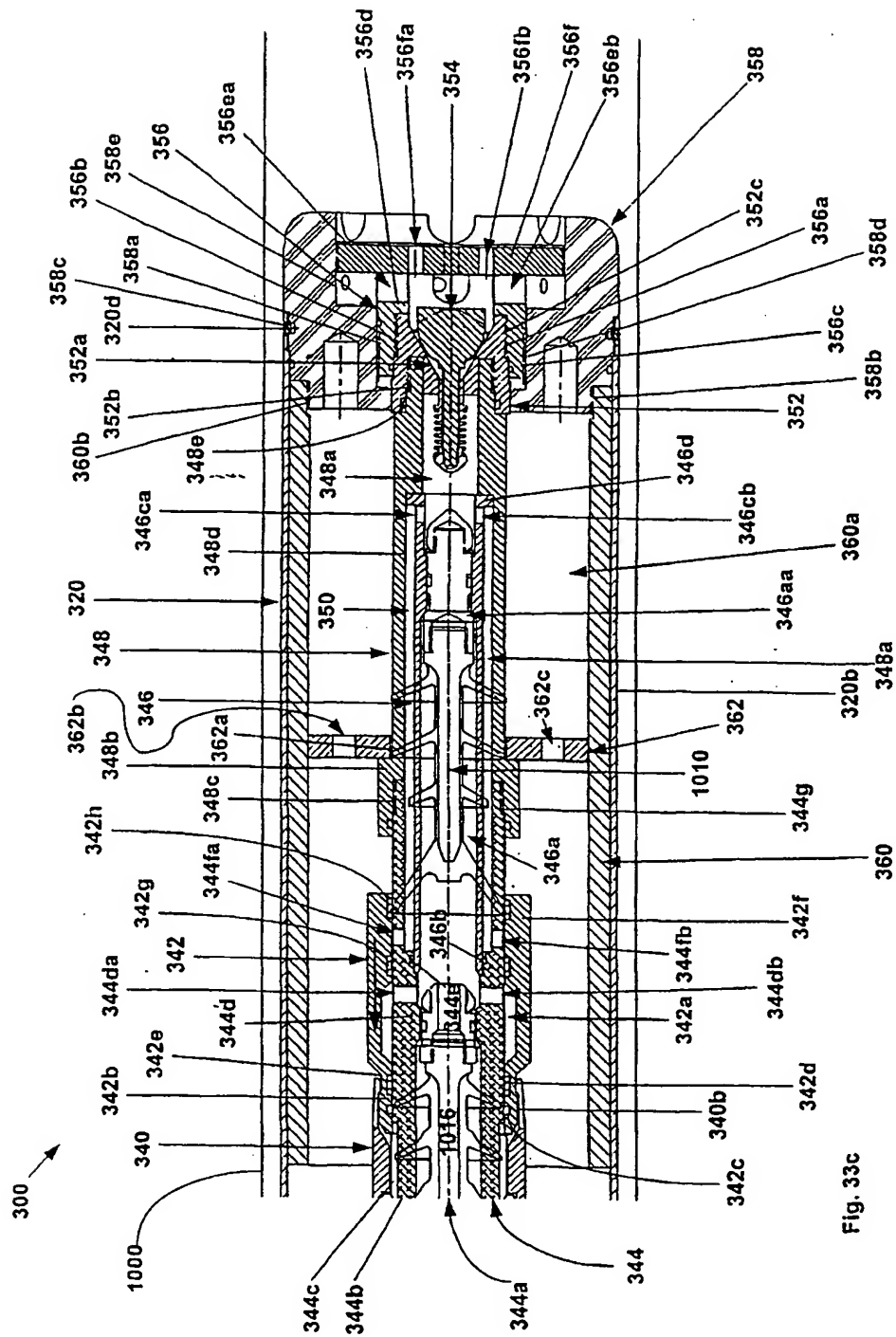
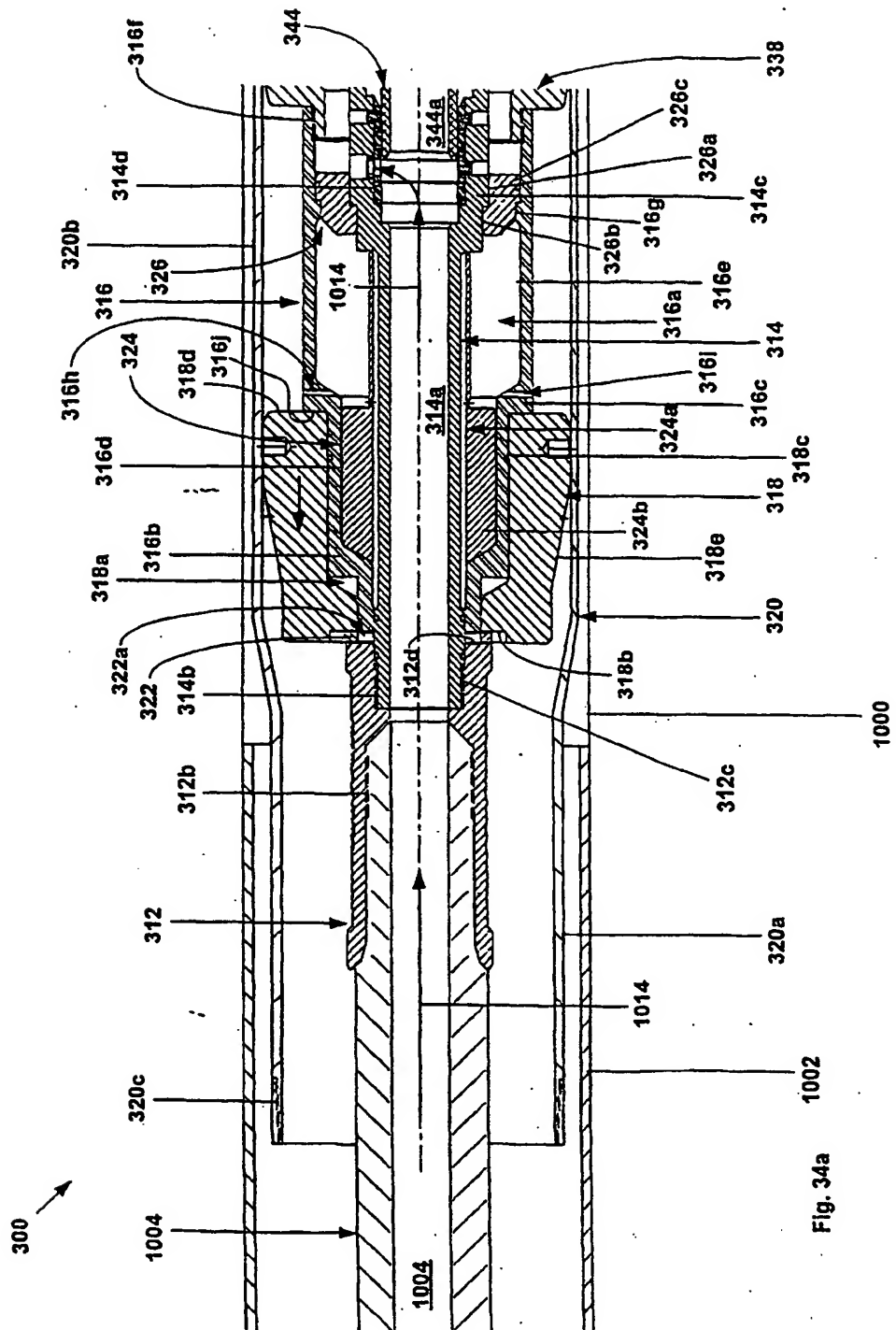


Fig. 33c





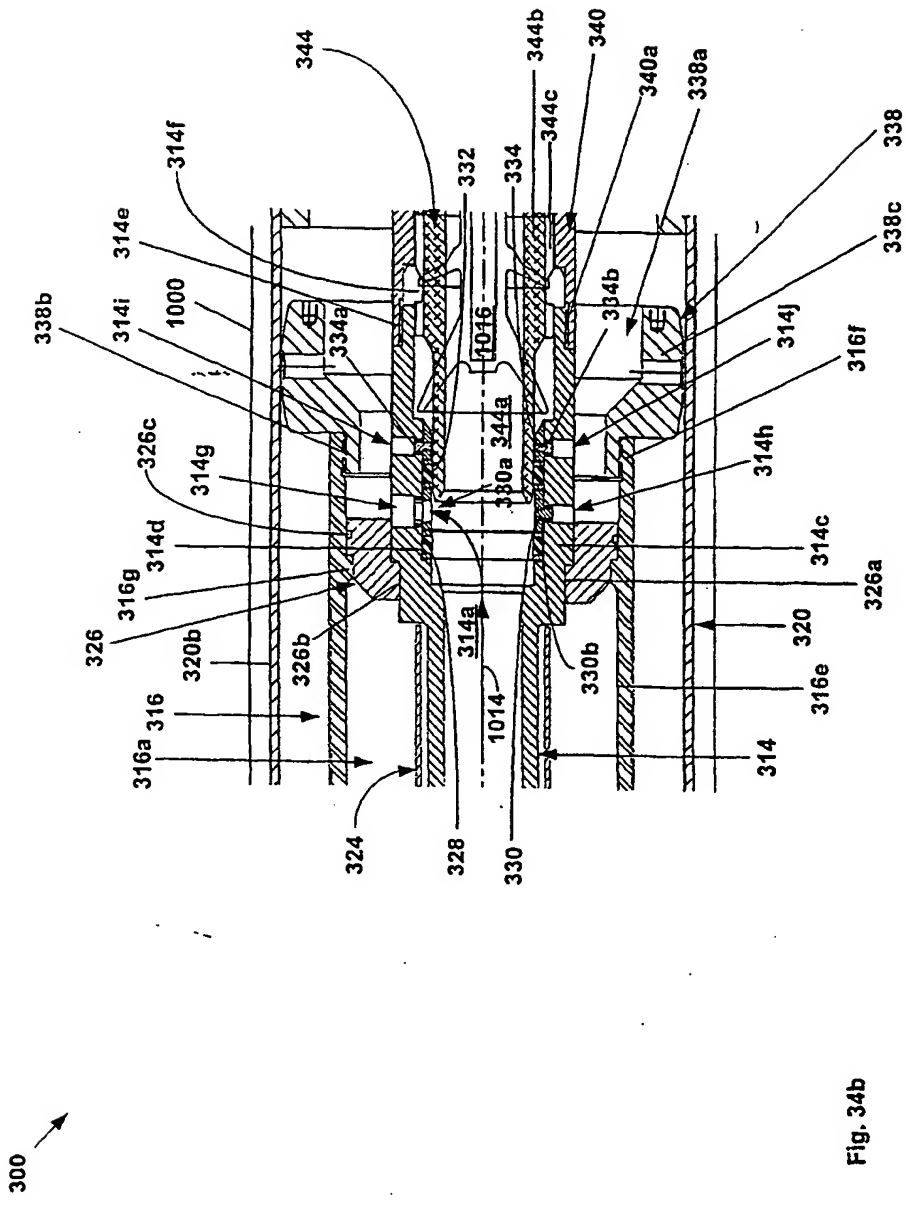
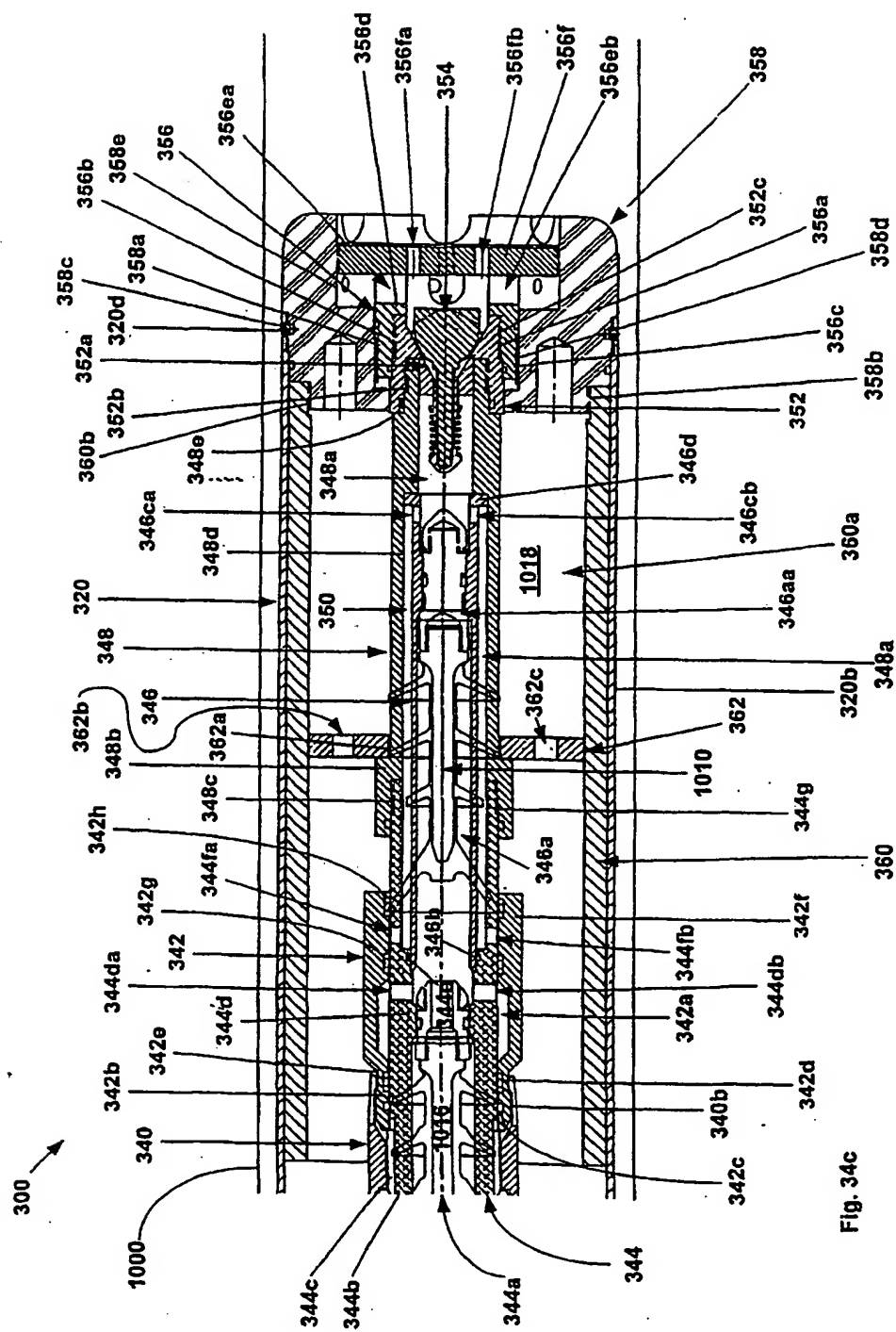


Fig. 34b



## LINER HANGER WITH SLIDING SLEEVE VALVE

## Cross Reference To Related Applications

5 This application claims the benefit of the filing date of U.S. provisional patent application serial number 60/233,638, attorney docket number 25791.47, filed on 9/18/2000, the disclosure of which is incorporated herein by reference.

This application is related to the following co-pending applications: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) U.S. patent application serial no. \_\_\_\_\_, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. \_\_\_\_\_, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. \_\_\_\_\_, attorney docket no. 25791.45, filed on 7/28/2000, and (19) U.S. provisional patent application serial no. \_\_\_\_\_, attorney docket no. 25791.46, filed on 7/28/2000. Applicants incorporate by reference the disclosures of these applications.

## Background of the Invention

This invention relates generally to wellbore casings, and in particular to wellbore casings that are formed using expandable tubing.

Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming wellbores.

## Summary of the Invention

According to one aspect of the invention, a method of forming a wellbore casing within a borehole within a subterranean formation is provided that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, a method of forming a wellbore casing within a borehole within a subterranean formation is provided that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

According to another aspect of the present invention, an apparatus for forming a wellbore casing in a borehole in a subterranean formation is provided that includes means for radially expanding an expandable tubular member and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

According to another aspect of the present invention, a method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided. The apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled

to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member.

According to another aspect of the present invention, a method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation is provided in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages

and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

According to one aspect of the invention, a method of coupling an expandable tubular member to a preexisting structure is provided that includes positioning an expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

According to another aspect of the present invention, a method of coupling an expandable tubular member to a preexisting structure is provided that includes positioning the expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at



least a portion of the tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion  
5 of the tubular member.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for  
10 fluidically isolating a first region from a second region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling  
15 the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes a  
20 first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an  
25 annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and  
30 movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

According to another aspect of the present invention, an apparatus for coupling an expandable tubular member to a preexisting structure is provided that includes means for radially expanding an expandable tubular member and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

According to another aspect of the present invention, a method of operating an apparatus for coupling an expandable tubular member to a preexisting structure is provided. The apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member.

According to another aspect of the present invention, a method of operating an apparatus for coupling an expandable tubular member to a preexisting structure is

provided in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

#### Brief Description of the Drawings

Figs. 1 and 1a-1c are cross sectional illustrations of an embodiment of a liner hanger assembly including a sliding sleeve valve assembly.

Figs. 2a-2b is a flow chart illustration of an embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 1 and 1a-1c.

Figs. 3a-3c are cross sectional illustrations of the placement of the liner hanger assembly of Figs. 1 and 1a-1c into a wellbore.

Figs. 4a-4c are cross sectional illustrations of the injection of a fluidic materials into the liner hanger assembly of Figs. 3a-3c.

Figs. 5a-5c are cross sectional illustrations of the placement of a bottom plug into the liner hanger assembly of Figs. 4a-4c.

5 Figs. 6a-6c are cross sectional illustrations of the downward displacement of sliding sleeve of the liner hanger assembly of Figs. 5a-5c.

Figs. 7a-7c are cross sectional illustrations of the injection of a hardenable fluidic sealing material into the liner hanger assembly of Figs. 6a-6c that bypasses the plug.

10 Figs. 8a-8c are cross sectional illustrations of the placement of a top plug into the liner hanger assembly of Figs. 7a-7c.

Figs. 9a-9c are cross sectional illustrations of the upward displacement of sliding sleeve of the liner hanger assembly of Figs. 8a-8c.

15 Figs. 10a-10c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 9a-9c in order to radially expand and plastically deform the expansion cone launcher.

Figs. 11a-11b is a flow chart illustration of an alternative embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 1 and 1a-1c.

20 Figs. 12a-12c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 5a-5c in order to at least partially radially expand and plastically deform the expansion cone launcher.

Figs. 13a-13c are cross sectional illustrations of the downward displacement of the sliding sleeve of the liner hanger assembly of Figs. 12a-12c.

25 Figs. 14a-14c are cross sectional illustrations of the injection of a hardenable fluidic sealing material through the liner hanger assembly of Figs. 13a-13c.

Figs. 15a-15c are cross sectional illustrations of the injection and placement of a top plug into the liner hanger assembly of Figs. 14a-14c.

30 Figs. 16a-16c are cross sectional illustrations of the upward displacement of the sliding sleeve of the liner hanger assembly of Figs. 15a-15c.

Figs. 17a-17c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 16a-16c in order to complete the radial expansion of the expansion cone launcher.

Figs. 18, 18a, 18b, and 18c are cross sectional illustrations of an alternative embodiment of a liner hanger assembly including a sliding sleeve valve assembly.

Figs. 19a-19b is a flow chart illustration of an embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 18 and 18a-18c.

5 Figs. 20a-20c are cross sectional illustrations of the placement of the liner hanger assembly of Figs. 18 and 18a-18c into a wellbore.

Figs. 21a-21c are cross sectional illustrations of the injection of a fluidic materials into the liner hanger assembly of Figs. 20a-20c.

10 Figs. 22a-22c are cross sectional illustrations of the placement of a bottom plug into the liner hanger assembly of Figs. 21a-21c.

Figs. 23a-23c are cross sectional illustrations of the downward displacement of sliding sleeve of the liner hanger assembly of Figs. 22a-22c.

15 Figs. 24a-24c are cross sectional illustrations of the injection of a hardenable fluidic sealing material into the liner hanger assembly of Figs. 23a-23c that bypasses the bottom plug.

Figs. 25a-25c are cross sectional illustrations of the placement of a top plug into the liner hanger assembly of Figs. 24a-24c.

Figs. 26a-26c are cross sectional illustrations of the upward displacement of sliding sleeve of the liner hanger assembly of Figs. 25a-25c.

20 Figs. 27a-27c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 26a-26c in order to radially expand and plastically deform the expansion cone launcher.

25 Figs. 28a-28b is a flow chart illustration of an alternative embodiment of a method for forming a wellbore casing using the liner hanger assembly of Figs. 18 and 18a-18c.

Figs. 29a-29c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 22a-22c in order to at least partially radially expand and plastically deform the expansion cone launcher.

30 Figs. 30a-30c are cross sectional illustrations of the downward displacement of the sliding sleeve of the liner hanger assembly of Figs. 29a-29c.

Figs. 31a-31c are cross sectional illustrations of the injection of a hardenable fluidic sealing material through the liner hanger assembly of Figs. 30a-30c.

Figs. 32a-32c are cross sectional illustrations of the injection and placement of a top plug into the liner hanger assembly of Figs. 31a-31c.

Figs. 33a-33c are cross sectional illustrations of the upward displacement of the sliding sleeve of the liner hanger assembly of Figs. 32a-32c.

- 5 Figs. 34a-34c are cross sectional illustrations of the injection of a pressurized fluidic material into the liner hanger assembly of Figs. 33a-33c in order to complete the radial expansion of the expansion cone launcher.

#### Detailed Description

- 10 A liner hanger assembly having sliding sleeve bypass valve is provided. In several alternative embodiments, the liner hanger assembly provides a method and apparatus for forming or repairing a wellbore casing, a pipeline or a structural support.

- Referring initially to Figs. 1, 1a, 1b, and 1c, an embodiment of a liner hanger assembly 10 includes a first tubular support member 12 defining an internal passage 12a that includes a threaded counterbore 12b at one end, and a threaded counterbore 12c at another end. A second tubular support member 14 defining an internal passage 14a includes a first threaded portion 14b at a first end that is coupled to the threaded counterbore 12c of the first tubular support member 12, a stepped flange 14c, a counterbore 14d, a threaded portion 14e, and internal splines 14f at another end. The stepped flange 14c of the second tubular support member 14 further defines radial passages 14g, 14h, 14i, and 14j. A third tubular support member 16 defining an internal passage 16a for receiving the second tubular support member 14 includes a first flange 16b, a second flange 16c, a first counterbore 16d, a second counterbore 16e having an internally threaded portion 16f, and an internal flange 16g. The second flange 16c further includes radial passages 16h and 16i.

- 25 An annular expansion cone 18 defining an internal passage 18a for receiving the second and third tubular support members, 14 and 16, includes a counterbore 18b at one end, and a counterbore 18c at another end for receiving the flange 16b of the second tubular support member 16. The annular expansion cone 18 further includes an end face 18d that mates with an end face 16j of the flange 16c of the second tubular support member 16, and an exterior surface 18e having a conical shape in order to facilitate the radial expansion of tubular members. A tubular expansion cone launcher 20 is movably coupled to the exterior surface 18e of the expansion cone 18 and includes a first portion 20a having a first wall thickness, a second portion 20b having a

second wall thickness, a threaded portion 20c at one end, and a threaded portion 20d at another end. In a preferred embodiment, the second portion 20b of the expansion cone launcher 20 mates with the conical outer surface 18e of the expansion cone 18. In a preferred embodiment, the second wall thickness is less than the first wall thickness in order to optimize the radial expansion of the expansion cone launcher 20 by the relative axial displacement of the expansion cone 18. In a preferred embodiment, one or more expandable tubulars are coupled to the threaded connection 20c of the expansion cone launcher 20. In this manner, the assembly 10 may be used to radially expand and plastically deform, for example, thousands of feet of expandable tubulars.

10 An annular spacer 22 defining an internal passage 22a for receiving the second tubular support member 14 is received within the counterbore 18b of the expansion cone 18, and is positioned between an end face 12d of the first tubular support member 12 and an end face of the counterbore 18b of the expansion cone 18. A fourth tubular support member 24 defining an internal passage 24a for receiving the second tubular support member 14 includes a flange 24b that is received within the counterbore 16d of the third tubular support member 16. A fifth tubular support member 26 defining an internal passage 26a for receiving the second tubular support member 14 includes an internal flange 26b for mating with the flange 14c of the second tubular support member and a flange 26c for mating with the internal flange 16g of the third tubular support member 16.

20 An annular sealing member 28, an annular sealing and support member 30, an annular sealing member 32, and an annular sealing and support member 34 are received within the counterbore 14d of the second tubular support member 14. The annular sealing and support member 30 further includes a radial opening 30a for supporting a rupture disc 36 within the radial opening 14g of the second tubular support member 14 and a sealing member 30b for sealing the radial opening 14h of the second tubular support member. The annular sealing and support member 34 further includes sealing members 34a and 34b for sealing the radial openings 14i and 14j, respectively, of the second tubular support member 14. In an exemplary embodiment, the rupture disc 36 opens when the operating pressure within the radial opening 30b is about 1000 to 5000 psi. In this manner, the rupture disc 36 provides a pressure sensitive valve for controlling the flow of fluidic materials through the radial opening

30a. In several alternative embodiments, the assembly 10 includes a plurality of radial passages 30a, each with corresponding rupture discs 36.

5 A sixth tubular support member 38 defining an internal passage 38a for receiving the second tubular support member 14 includes a threaded portion 38b at one end that is coupled to the threaded portion 16f of the third tubular support member 16 and a flange 38c at another end that is movably coupled to the interior of the expansion cone launcher 20. An annular collet 40 includes a threaded portion 40a that is coupled to the threaded portion 14e of the second tubular support member 14, and a resilient coupling 40b at another end.

10 An annular sliding sleeve 42 defining an internal passage 42a includes an internal flange 42b, having sealing members 42c and 42d, and an external groove 42e for releasably engaging the coupling 40b of the collet 40 at one end, and an internal flange 42f, having sealing members 42g and 42h, at another end. During operation the coupling 40b of the collet 40 may engage the external groove 42e of the sliding sleeve  
15 42 and thereby displace the sliding sleeve in the longitudinal direction. Since the coupling 40b of the collet 40 is resilient, the collet 40 may be disengaged or reengaged with the sliding sleeve 42. An annular valve member 44 defining an internal passage 44a, having a first throat 44aa and a second throat 44ab, includes a flange 44b at one end, having external splines 44c for engaging the internal splines 14f of the second  
20 tubular support member 14, a first set of radial passages, 44da and 44db, a second set of radial passages, 44ea and 44eb, and a threaded portion 44f at another end. The sliding sleeve 42 and the valve member 44 define an annular bypass passage 46 that, depending upon the position of the sliding sleeve 42, permits fluidic materials to flow from the passage 44 through the first radial passages, 44da and 44db, the bypass  
25 passage 46, and the second radial passages, 44ea and 44eb, back into the passage 44. In this manner, fluidic materials may bypass the portion of the passage 44 between the first and second radial passages, 44ea, 44eb, 44da, and 44db. Furthermore, the sliding sleeve 42 and the valve member 44 together define a sliding sleeve valve for controllably permitting fluidic materials to bypass the intermediate portion of the  
30 passage 44a between the first and second passages, 44da, 44db, 44ea, and 44eb. During operation, the flange 44b limits movement of the sliding sleeve 42 in the longitudinal direction.



In a preferred embodiment, the collet 40 includes a set of couplings 40b such as, for example, fingers, that engage the external groove 42e of the sliding sleeve 42. During operation, the collet couplings 40b latch over and onto the external groove 42e of the sliding sleeve 42. In a preferred embodiment, a longitudinal force of at least about 10,000 to 13,000 lbf is required to pull the couplings 40b off of, and out of engagement with, the external groove 42e of the sliding sleeve 42. In an exemplary embodiment, the application of a longitudinal force less than about 10,000 to 13,000 lbf indicates that the collet couplings 40b are latched onto the external shoulder of the sliding sleeve 42, and that the sliding sleeve 42 is in the up or the down position relative to the valve member 44. In a preferred embodiment, the collet 40 includes a conventional internal shoulder that transfers the weight of the first tubular support member 12 and expansion cone 18 onto the sliding sleeve 42. In a preferred embodiment, the collet 40 further includes a conventional set of internal lugs for engaging the splines 44c of the valve member 44.

An annular valve seat 48 defining a conical internal passage 48a for receiving a conventional float valve element 50 includes an annular recess 48b, having an internally threaded portion 48c for engaging the threaded portion 44f of the valve member 44, at one end, and an externally threaded portion 48d at another end. In an alternative embodiment, the float valve element 50 is omitted. An annular valve seat mounting element 52 defining an internal passage 52a for receiving the valve seat 48 and float valve 50 includes an internally threaded portion 52b for engaging the externally threaded portion 48d of the valve seat 48, an externally threaded portion 52c, an internal flange 52d, radial passages, 52ea and 52eb, and an end member 52f, having axial passages, 52fa and 52fb.

A shoe 54 defining an internal passage 54a for receiving the valve seat mounting element 52 includes a first annular recess 54b, having an externally threaded portion 54c, and a second annular recess 54d, having an externally threaded portion 54e for engaging the threaded portion 20d of the expansion cone launcher 20, at one end, a first threaded counterbore 54f for engaging the threaded portion 52c of the of the mounting element, and a second counterbore 54g for mating with the end member 52f of the mounting element. In a preferred embodiment, the shoe 54 is fabricated from a ceramic and/or a composite material in order to facilitate the subsequent removal of the shoe by drilling. A seventh tubular support member 56 defining an

internal passage 56a for receiving the sliding sleeve 42 and the valve member 44 is positioned within the expansion cone launcher 20 that includes an internally threaded portion 56b at one end for engaging the externally threaded portion 54c of the annular recess 54b of the shoe 54. In a preferred embodiment, during operation of the assembly, the end of the seventh tubular support member 56 limits the longitudinal movement of the expansion cone 18 in the direction of the shoe 54 by limiting the longitudinal movement of the sixth tubular support member 38. An annular centralizer 58 defining an internal passage 58a for movably supporting the sliding sleeve 42 is positioned within the seventh tubular support member 56 that includes axial passages 58b and 58c. In a preferred embodiment, the centralizer 58 maintains the sliding sleeve 42 and valve member 44 in a central position within the assembly 10.

Referring to Figs. 2a-2b, during operation, the assembly 10 may be used to form or repair a wellbore casing by implementing a method 200 in which, as illustrated in Figs. 3a-3c, the assembly 10 may initially be positioned within a wellbore 100 having a preexisting wellbore casing 102 by coupling a conventional tubular member 104 defining an internal passage 104a to the threaded portion 12b of the first tubular support member 12 in step 202. In a preferred embodiment, during placement of the assembly 10 within the wellbore 100, fluidic materials 106 within the wellbore 100 below the assembly 10 are conveyed through the assembly 10 and into the passage 104a by the fluid passages 52fa, 52fb, 54a, 48a, 44a, and 14a. In this manner, surge pressures that can be created during placement of the assembly 10 within the wellbore 100 are minimized. In a preferred embodiment, the float valve element 50 is pre-set in an auto-fill configuration to permit the fluidic materials 106 to pass through the conical passage 48a of the valve seat 48.

Referring to Figs. 4a-4c, in step 204, fluidic materials 108 may then be injected into and through the tubular member 104 and assembly 10 to thereby ensure that all of the fluid passages 104a, 14a, 44a, 48a, 54a, 52fa, and 52fb are functioning properly.

Referring to Figs. 5a-5c, in step 206, a bottom plug 110 may then be injected into the fluidic materials 108 and into the assembly 10 and then positioned in the throat passage 44ab of the valve member 44. In this manner, the region of the passage 44a upstream from the plug 110 may be fluidically isolated from the region of the passage 44a downstream from the plug 110. In a preferred embodiment, the proper placement

of the plug 110 may be indicated by a corresponding increase in the operating pressure of the fluidic material 108.

Referring to Figs. 6a-6c, in step 208, the sliding sleeve 42 may then be displaced relative to the valve member 44 by displacing the tubular member 104 by applying, for example, a downward force of approximately 5,000 lbf on the assembly 10. In this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the rupture disc 36 is fluidically isolated from the passages 14a and 44a.

Referring to Figs. 7a-7c, in step 210, a hardenable fluidic sealing material 112 may then be injected into the assembly 10 and conveyed through the passages 104a, 14a, 44a, 44da, 44db, 46, 44ea, 44eb, 48a, 54a, 52fa, and 52fb into the wellbore 100. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 20 and the wellbore 100 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 20. Furthermore, in this manner, the radial passage 30a and the rupture disc 36 are not exposed to the hardenable fluidic sealing material 112.

Referring to Figs. 8a-8c, in step 212, upon the completion of the injection of the hardenable fluidic sealing material 112, a nonhardenable fluidic material 114 may be injected into the assembly 10, and a top plug 116 may then be injected into the assembly 10 along with the fluidic materials 114 and then positioned in the throat passage 44aa of the valve member 44. In this manner, the region of the passage 44a upstream from the first passages, 44da and 44db, may be fluidically isolated from the first passages. In a preferred embodiment, the proper placement of the plug 116 may

be indicated by a corresponding increase in the operating pressure of the fluidic material 114.

Referring to Fig. 9a-9c, in step 214, the sliding sleeve 42 may then be displaced relative to the valve member 44 by displacing the tubular member 104 by applying, for example, an upward force of approximately 13,000 lbf on the assembly 10. In this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may no longer bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the rupture disc 36 is no longer fluidically isolated from the fluid passages 14a and 44a.

Referring to Figs. 10a-10c, in step 216, the fluidic material 114 may be injected into the assembly 10. The continued injection of the fluidic material 114 may increase the operating pressure within the passages 14a and 44a until the burst disc 36 is opened thereby permitting the pressurized fluidic material 114 to pass through the radial passage 30a and into an annular region 118 defined by the second tubular support member 14, the third tubular support member 16, the sixth tubular support member 38, the collet 40, the sliding sleeve 42, the shoe 54, and the seventh tubular support member 56. The pressurized fluidic material 114 within the annular region 118 directly applies a longitudinal force upon the fifth tubular support member 26 and the sixth tubular support member 38. The longitudinal force in turn is applied to the expansion cone 18. In this manner, the expansion cone 18 is displaced relative to the expansion cone launcher 20 thereby radially expanding and plastically deforming the expansion cone launcher.

In an alternative embodiment of the method 200, the injection and placement of the top plug 116 into the liner hanger assembly 10 in step 212 may be omitted.

In an alternative embodiment of the method 200, in step 202, the assembly 10 is positioned at the bottom of the wellbore 100.

In an alternative embodiment, as illustrated in Figs. 11a-11b, during operation, the assembly 10 may be used to form or repair a wellbore casing by implementing a method 250 in which, as illustrated in Figs. 3a-3c, the assembly 10 may initially be positioned within a wellbore 100 having a preexisting wellbore casing 102 by coupling  
5 a conventional tubular member 104 defining an internal passage 104a to the threaded portion 12b of the first tubular support member 12 in step 252. In a preferred embodiment, during placement of the assembly 10 within the wellbore 100, fluidic materials 106 within the wellbore 100 below the assembly 10 are conveyed through the assembly 10 and into the passage 104a by the fluid passages 52fa, 52fb, 54a, 48a,  
10 44a, and 14a. In this manner, surge pressures that can be created during placement of the assembly 10 within the wellbore 100 are minimized. In a preferred embodiment, the float valve element 50 is pre-set in an auto-fill configuration to permit the fluidic materials 106 to pass through the conical passage 48a of the valve seat 48.

Referring to Figs. 4a-4c, in step 254, fluidic materials 108 may then be injected  
15 into and through the tubular member 104 and assembly 10 to thereby ensure that all of the fluid passages 104a, 14a, 44a, 48a, 54a, 52fa, and 52fb are functioning properly.

Referring to Figs. 5a-5c, in step 256, the bottom plug 110 may then be injected into the fluidic materials 108 and into the assembly 10 and then positioned in the throat passage 44ab of the valve member 44. In this manner, the region of the passage 44a  
20 upstream from the plug 110 may be fluidically isolated from the region of the passage 44a downstream from the plug 110. In a preferred embodiment, the proper placement of the plug 110 may be indicated by a corresponding increase in the operating pressure of the fluidic material 108.

Referring to Figs. 12a-12c, in step 258, a fluidic material 114 may then be  
25 injected into the assembly to thereby increase the operating pressure within the passages 14a and 44a until the burst disc 36 is opened thereby permitting the pressurized fluidic material 114 to pass through the radial passage 30a and into an annular region 118 defined by the second tubular support member 14, the third tubular support member 16, the sixth tubular support member 38, the collet 40, the sliding  
30 sleeve 42, the shoe 54, and the seventh tubular support member 56. The pressurized fluidic material 114 within the annular region 118 directly applies a longitudinal force upon the fifth tubular support member 26 and the sixth tubular support member 38. The longitudinal force in turn is applied to the expansion cone 18. In this manner, the

expansion cone 18 is displaced relative to the expansion cone launcher 20 thereby disengaging the collet 40 and the sliding sleeve 42 and radially expanding and plastically deforming the expansion cone launcher. In a preferred embodiment, the radial expansion process in step 408 is continued to a location below the overlap  
5 between the expansion cone launcher 20 and the preexisting wellbore casing 102.

Referring to Figs. 13a-13c, in step 260, the sliding sleeve 42 may then be displaced relative to the valve member 44 by (1) displacing the expansion cone 18 in a downward direction using the tubular member 104 and (2) applying, using the tubular member 104 a downward force of, for example, approximately 5,000 lbf on the  
10 assembly 10. In this manner, the coupling 40b of the collet 40 reengages the external groove 42e of the sliding sleeve 42. Furthermore, in this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth  
15 tubular support member 38; the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of  
20 the passage 44a downstream from the plug. Furthermore, in this manner, the fluid passage 30a is fluidically isolated from the passages 14a and 44a.

Referring to Figs. 14a-14c, in step 262, the hardenable fluidic sealing material 112 may then be injected into the assembly 10 and conveyed through the passages 104a, 14a, 44a, 44da, 44db, 46, 44ea, 44eb, 48a, 54a, 52fa, and 52fb into the wellbore  
25 100. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 20 and the wellbore 100 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 20. Furthermore, in this manner, the radial passage 30a and the rupture disc 36 are not exposed to the  
30 hardenable fluidic sealing material 112.

Referring to Figs. 15a-15c, in step 264, upon the completion of the injection of the hardenable fluidic sealing material 112, the nonhardenable fluidic material 114 may be injected into the assembly 10, and the top plug 116 may then be injected into

the assembly 10 along with the fluidic materials 114 and then positioned in the throat passage 44aa of the valve member 44. In this manner, the region of the passage 44a upstream from the first passages, 44da and 44db, may be fluidically isolated from the first passages. In a preferred embodiment, the proper placement of the plug 116 may  
5 be indicated by a corresponding increase in the operating pressure of the fluidic material 114.

Referring to Figs. 16a-16c, in step 266, the sliding sleeve 42 may then be displaced relative to the valve member 44 by displacing the tubular member 104 by applying, for example, an upward force of approximately 13,000 lbf on the assembly  
10 10. In this manner, the tubular member 104, the first tubular support member 12, the second tubular support member 14, the third tubular support member 16, the expansion cone 18, the annular spacer 22, the fourth tubular support member 24, the fifth tubular support member 26, the sixth tubular support member 38, the collet 40, and the sliding sleeve 42 are displaced in the longitudinal direction relative to the expansion cone  
15 launcher 20 and the valve member 44. In this manner, fluidic materials within the passage 44a upstream of the plug 110 may no longer bypass the plug by passing through the first passages, 44da and 44db, through the annular passage 46, and through the second passages, 44ea and 44eb, into the region of the passage 44a downstream from the plug. Furthermore, in this manner, the passage 30a is no longer fluidically  
20 isolated from the fluid passages 14a and 44a.

Referring to Figs. 17a-17c, in step 268, the fluidic material 114 may be injected into the assembly 10. The continued injection of the fluidic material 114 may increase the operating pressure within the passages 14a, 30a, and 44a and the annular region 118. The pressurized fluidic material 114 within the annular region 118 directly  
25 applies a longitudinal force upon the fifth tubular support member 26 and the sixth tubular support member 38. The longitudinal force in turn is applied to the expansion cone 18. In this manner, the expansion cone 18 is displaced relative to the expansion cone launcher 20 thereby completing the radial expansion of the expansion cone launcher.

30 In an alternative embodiment of the method 250, the injection and placement of the top plug 116 into the liner hanger assembly 10 in step 264 may be omitted.

In an alternative embodiment of the method 250, in step 252, the assembly 10 is positioned at the bottom of the wellbore 100.

In an alternative embodiment of the method 250: (1) in step 252, the assembly 10 is positioned proximate a position below a preexisting section of the wellbore casing 102, and (2) in step 258, the expansion cone launcher 20, and any expandable tubulars coupled to the threaded portion 20c of the expansion cone launcher, are  
5 radially expanded and plastically deformed until the shoe 54 of the assembly 10 is proximate the bottom of the wellbore 100. In this manner, the radial expansion process using the assembly 10 provides a telescoping of the radially expanded tubulars into the wellbore 100.

In several alternative embodiments, the assembly 10 may be operated to form a  
10 wellbore casing by including or excluding the float valve 50.

In several alternative embodiments, the float valve 50 may be operated in an auto-fill configuration in which tabs are positioned between the float valve 50 and the valve seat 48. In this manner, fluidic materials within the wellbore 100 may flow into the assembly 10 from below thereby decreasing surge pressures during placement of  
15 the assembly 10 within the wellbore 100. Furthermore, pumping fluidic materials through the assembly 10 at rate of about 6 to 8 bbl/min will displace the tabs from the valve seat 48 and thereby allow the float valve 50 to close.

In several alternative embodiments, prior to the placement of any of the plugs, 110 and 116, into the assembly 10, fluidic materials can be circulated through the  
20 assembly 10 and into the wellbore 100.

In several alternative embodiments, once the bottom plug 110 has been positioned into the assembly 10, fluidic materials can only be circulated through the assembly 10 and into the wellbore 100 if the sliding sleeve 42 is in the down position.

In several alternative embodiments, once the sliding sleeve 42 is positioned in  
25 the down position, the passage 30a and rupture disc 36 are fluidically isolated from pressurized fluids within the assembly 10.

In several alternative embodiments, once the top plug 116 has been positioned into the assembly 10, no fluidic materials can be circulated through the assembly 10 and into the wellbore 100.

30 In several alternative embodiments, the assembly 10 may be operated to form or repair a wellbore casing, a pipeline, or a structural support.

Referring to Figs. 18, 18a, 18b, and 18c, an alternative embodiment of a liner hanger assembly 300 includes a first tubular support member 312 defining an internal



passage 312a that includes a threaded counterbore 312b at one end, and a threaded counterbore 312c at another end. A second tubular support member 314 defining an internal passage 314a includes a first threaded portion 314b at a first end that is coupled to the threaded counterbore 312c of the first tubular support member 312, a stepped flange 314c, a counterbore 314d, a threaded portion 314e, and internal splines 314f at another end. The stepped flange 314c of the second tubular support member 314 further defines radial passages 314g, 314h, 314i, and 314j.

A third tubular support member 316 defining an internal passage 316a for receiving the second tubular support member 314 includes a first flange 316b, a second flange 316c, a first counterbore 316d, a second counterbore 316e having an internally threaded portion 316f, and an internal flange 316g. The second flange 316c further includes radial passages 316h and 316i.

An annular expansion cone 318 defining an internal passage 318a for receiving the second and third tubular support members, 314 and 316, includes a counterbore 318b at one end, and a counterbore 318c at another end for receiving the flange 316b of the second tubular support member 316. The annular expansion cone 318 further includes an end face 318d that mates with an end face 316j of the flange 316c of the second tubular support member 316, and an exterior surface 318e having a conical shape in order to facilitate the radial expansion of tubular members. A tubular expansion cone launcher 320 is movably coupled to the exterior surface 318e of the expansion cone 318 and includes a first portion 320a having a first wall thickness, a second portion 320b having a second wall thickness, a threaded portion 320c at one end, and a threaded portion 320d at another end. In a preferred embodiment, the second portion 320b of the expansion cone launcher 320 mates with the conical outer surface 318e of the expansion cone 318. In a preferred embodiment, the second wall thickness of the second portion 320b is less than the first wall thickness of the first portion 320a in order to optimize the radial expansion of the expansion cone launcher 320 by the relative axial displacement of the expansion cone 318. In a preferred embodiment, one or more expandable tubulars are coupled to the threaded connection 320c of the expansion cone launcher 320. In this manner, the assembly 300 may be used to radially expand and plastically deform, for example, thousands of feet of expandable tubulars.

An annular spacer 322 defining an internal passage 322a for receiving the second tubular support member 314 is received within the counterbore 318b of the expansion cone 318, and is positioned between an end face 312d of the first tubular support member 312 and an end face of the counterbore 318b of the expansion cone 318. A fourth tubular support member 324 defining an internal passage 324a for receiving the second tubular support member 314 includes a flange 324b that is received within the counterbore 316d of the third tubular support member 316. A fifth tubular support member 326 defining an internal passage 326a for receiving the second tubular support member 314 includes an internal flange 326b for mating with the flange 314c of the second tubular support member and a flange 326c for mating with the internal flange 316g of the third tubular support member 316.

An annular sealing member 328, an annular sealing and support member 330, an annular sealing member 332, and an annular sealing and support member 334 are received within the counterbore 314d of the second tubular support member 314. The annular sealing and support member 330 further includes a radial opening 330a for supporting a rupture disc 336 within the radial opening 314g of the second tubular support member 314 and a sealing member 330b for sealing the radial opening 314h of the second tubular support member. The annular sealing and support member 334 further includes sealing members 334a and 334b for sealing the radial openings 314i and 314j, respectively, of the second tubular support member 314. In an exemplary embodiment, the rupture disc 336 opens when the operating pressure within the radial opening 330b is about 1000 to 5000 psi. In this manner, the rupture disc 336 provides a pressure sensitive valve for controlling the flow of fluidic materials through the radial opening 330a. In several alternative embodiments, the assembly 300 includes a plurality of radial passages 330a, each with corresponding rupture discs 336.

A sixth tubular support member 338 defining an internal passage 338a for receiving the second tubular support member 314 includes a threaded portion 338b at one end that is coupled to the threaded portion 316f of the third tubular support member 316 and a flange 338c at another end that is movably coupled to the interior of the expansion cone launcher 320. An annular collet 340 includes a threaded portion 340a that is coupled to the threaded portion 314e of the second tubular support member 314, and a resilient coupling 340b at another end.

An annular sliding sleeve 342 defining an internal passage 342a includes an internal flange 342b, having sealing members 342c and 342d, and an external groove 342e for releasably engaging the coupling 340b of the collet 340 at one end, and an internal flange 342f, having sealing members 342g and 342h, at another end. During  
5 operation, the coupling 340b of the collet 340 may engage the external groove 342e of the sliding sleeve 342 and thereby displace the sliding sleeve in the longitudinal direction. Since the coupling 340b of the collet 340 is resilient, the collet 340 may be disengaged or reengaged with the sliding sleeve 342. An annular valve member 344 defining an internal passage 344a, having a throat 344aa, includes a flange 344b at one  
10 end, having external splines 344c for engaging the internal splines 314f of the second tubular support member 314, an interior flange 344d having a first set of radial passages, 344da and 344db, and a counterbore 344e, a second set of radial passages, 344fa and 344fb, and a threaded portion 344g at another end.

An annular valve member 346 defining an internal passage 346a, having a  
15 throat 346aa, includes an end portion 346b that is received in the counterbore 344e of the annular valve member 344, a set of radial openings, 346ca and 346cb, and a flange 346d at another end. An annular valve member 348 defining an internal passage 348a for receiving the annular valve members 344 and 346 includes a flange 348b having a threaded counterbore 348c at one end for engaging the threaded portion 344g of the  
20 annular valve member, a counterbore 348d for mating with the flange 346d of the annular valve member, and a threaded annular recess 348e at another end.

The annular valve members 344, 346, and 348 define an annular passage 350 that fluidically couples the radial passages 344fa, 344fb, 346ca, and 346cb. Furthermore, depending upon the position of the sliding sleeve 342, the fluid passages,  
25 344da and 344db, may be fluidically coupled to the passages 344fa, 344fb, 346ca, 346cb, and 350. In this manner, fluidic materials may bypass the portion of the passage 346a between the passages 344da, 344db, 346ca, and 346cb. Furthermore, the sliding sleeve 342 and the valve members 344, 346, and 348 together define a  
30 sliding sleeve valve for controllably permitting fluidic materials to bypass the intermediate portion of the passage 346a between the passages, 344da, 344db, 346ca, and 346cb. During operation of the sliding sleeve valve, the flange 348b limits movement of the sliding sleeve 342 in the longitudinal direction.

In a preferred embodiment, the collet 340 includes a set of couplings 340b that engage the external groove 342e of the sliding sleeve 342. During operation, the collet couplings 340b latch over and onto the external groove 342e of the sliding sleeve 342. In a preferred embodiment, a longitudinal force of at least about 10,000 to 13,000 lbf is required to pull the couplings 340b off of, and out of engagement with, the external groove 342e of the sliding sleeve 342. In an exemplary embodiment, the application of a longitudinal force less than about 10,000 to 13,000 lbf indicates that the collet couplings 340b are latched onto the external shoulder of the sliding sleeve 342, and that the sliding sleeve 342 is in the up or the down position relative to the valve member 344. In a preferred embodiment, the collet 340 includes a conventional internal shoulder that transfers the weight of the first tubular support member 312 and expansion cone 318 onto the sliding sleeve 342. In a preferred embodiment, the collet 340 further includes a conventional set of internal lugs for engaging the splines 344c of the valve member 344.

15        An annular valve seat 352 defining a conical internal passage 352a for receiving a conventional float valve element 354 includes a threaded annular recess 352b for engaging the threaded portion 348e of the valve member 348, at one end, and an externally threaded portion 352c at another end. In an alternative embodiment, the float valve element 354 is omitted. An annular valve seat mounting element 356 defining an internal passage 356a for receiving the valve seat 352 and float valve 354 includes an internally threaded portion 356b for engaging the externally threaded portion 352c of the valve seat 352, an externally threaded portion 356c, an internal flange 356d, radial passages, 356ea and 356eb, and an end member 356f, having axial passages, 356fa and 356fb.

25        A shoe 358 defining an internal passage 358a for receiving the valve seat mounting element 356 includes a first threaded annular recess 358b, and a second threaded annular recess 358c for engaging the threaded portion 320d of the expansion cone launcher 320, at one end, a first threaded counterbore 358d for engaging the threaded portion 356c of the of the valve seat mounting element, and a second counterbore 358e for mating with the end member 356f of the mounting element. In a preferred embodiment, the shoe 358 is fabricated from a ceramic and/or a composite material in order to facilitate the subsequent removal of the shoe by drilling.

A seventh tubular support member 360 defining an internal passage 360a for receiving the sliding sleeve 342 and the valve members 344, 346, and 348 is positioned within the expansion cone launcher 320 that includes an internally threaded portion 360b at one end for engaging the externally threaded portion of the annular recess 358b of the shoe 358. In a preferred embodiment, during operation of the assembly, the end of the seventh tubular support member 360 limits the longitudinal movement of the expansion cone 318 in the direction of the shoe 358 by limiting the longitudinal movement of the sixth tubular support member 338. An annular centralizer 362 defining an internal passage 362 for supporting the valve member 348 is positioned within the seventh tubular support member 360 that includes axial passages 362b and 362c.

Referring to Figs. 19a-19b, during operation, the assembly 300 may be used to form or repair a wellbore casing by implementing a method 400 in which, as illustrated in Figs. 20a-20c, the assembly 300 may initially be positioned within a wellbore 1000 having a preexisting wellbore casing 1002 by coupling a conventional tubular member 1004 defining an internal passage 1004a to the threaded portion 312b of the first tubular support member 312 in step 402. In a preferred embodiment, during placement of the assembly 300 within the wellbore 1000, fluidic materials 1006 within the wellbore 1000 below the assembly 300 are conveyed through the assembly 300 and into the passage 1004a by the fluid passages 356fa, 356fb, 352a, 348a, 346a, 344a, and 314a. In this manner, surge pressures that can be created during placement of the assembly 300 within the wellbore 1000 are minimized. In a preferred embodiment, the float valve element 354 is pre-set in an auto-fill configuration to permit the fluidic materials 1006 to pass through the conical passage 352a of the valve seat 352.

Referring to Figs. 21a-21c, in step 404, fluidic materials 1008 may then be injected into and through the tubular member 1004 and assembly 300 to thereby ensure that all of the fluid passages 1004a, 314a, 344a, 346a, 348a, 352a, 356fa, and 356fb are functioning properly.

Referring to Figs. 22a-22c, in step 406, a bottom plug 1010 may then be injected into the fluidic materials 1008 and into the assembly 300 and then positioned in the throat passage 346aa of the valve member 346. In this manner, the region of the passage 346a upstream from the plug 1010 may be fluidically isolated from the region of the passage 346a downstream from the plug 1010. In a preferred embodiment, the

proper placement of the plug 1010 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1008.

Referring to Figs. 23a-23c, in step 408, the sliding sleeve 342 may then be displaced relative to the valve member 344 by displacing the tubular member 1004 by  
5 applying, for example, a downward force of approximately 5,000 lbf on the assembly 300. In this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet  
10 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the plug 1010 may bypass the plug by passing through the first passages, 344da and 344db, through the annular passage 342a, through the second passages, 344fa and 344fb, through the annular passage 350,  
15 through the passages, 346ca and 346cb, into the region of the passage 348a downstream from the plug. Furthermore, in this manner, the rupture disc 336 is fluidically isolated from the passages 314a and 344a.

Referring to Figs. 24a-24c, in step 410, a hardenable fluidic sealing material 1012 may then be injected into the assembly 300 and conveyed through the passages  
20 1004a, 314a, 344a, 344da, 344db, 342a, 344fa, 344fb, 350, 346ca, 346cb, 348a, 352a, 356fa, and 356fb into the wellbore 1000. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 320 and the wellbore 1000 in order to subsequently form an annular body of cement around the radially expanded expansion cone launcher 320.  
25 Furthermore, in this manner, the radial passage 330a and the rupture disc 336 are not exposed to the hardenable fluidic sealing material 1012.

Referring to Figs. 25a-25c, in step 412, upon the completion of the injection of the hardenable fluidic sealing material 1012, a nonhardenable fluidic material 1014 may be injected into the assembly 300, and a top plug 1016 may then be injected into  
30 the assembly 300 along with the fluidic materials 1014 and then positioned in the throat passage 344aa of the valve member 344. In this manner, the region of the passage 344a upstream from the top plug 1016 may be fluidically isolated from region downstream from the top plug. In a preferred embodiment, the proper placement of

the plug 1016 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1014.

Referring to Fig. 26a-26c, in step 414, the sliding sleeve 42 may then be displaced relative to the valve member 344 by displacing the tubular member 1004 by  
5 applying, for example, an upward force of approximately 13,000 lbf on the assembly 300. In this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet  
10 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the bottom plug 1010 may no longer bypass the bottom plug by passing through the first passages, 344da and 344db, through the annular passage 342a, through the second passages, 344fa and 344fb,  
15 through the annular passage 350, and through the passages, 346ca and 346cb, into region of the passage 348a downstream from the bottom plug. Furthermore, in this manner, the rupture disc 336 is no longer fluidically isolated from the fluid passages 314a and 344a.

Referring to Figs. 27a-27c, in step 416, the fluidic material 1014 may be  
20 injected into the assembly 300. The continued injection of the fluidic material 1014 may increase the operating pressure within the passages 314a and 344a until the burst disc 336 is opened thereby permitting the pressurized fluidic material 1014 to pass through the radial passage 330a and into an annular region 1018 defined by the second tubular support member 314, the third tubular support member 316, the sixth tubular  
25 support member 338, the collet 340, the sliding sleeve 342, the valve members, 344 and 348, the shoe 358, and the seventh tubular support member 360. The pressurized fluidic material 1014 within the annular region 1018 directly applies a longitudinal force upon the fifth tubular support member 326 and the sixth tubular support member 338. The longitudinal force in turn is applied to the expansion cone 318. In this  
30 manner, the expansion cone 318 is displaced relative to the expansion cone launcher 320 thereby radially expanding and plastically deforming the expansion cone launcher.

In an alternative embodiment of the method 400, the injection and placement of the top plug 1016 into the liner hanger assembly 300 in step 412 may be omitted.

In an alternative embodiment of the method 400, in step 402, the assembly 300 is positioned at the bottom of the wellbore 1000.

In an alternative embodiment, as illustrated in Figs. 28a-28b, during operation, the assembly 300 may be used to form or repair a wellbore casing by implementing a method 450 in which, as illustrated in Figs. 20a-20c, the assembly 300 may initially be positioned within a wellbore 1000 having a preexisting wellbore casing 1002 by coupling a conventional tubular member 1004 defining an internal passage 1004a to the threaded portion 312b of the first tubular support member 312 in step 452. In a preferred embodiment, during placement of the assembly 300 within the wellbore 1000, fluidic materials 1006 within the wellbore 1000 below the assembly 300 are conveyed through the assembly 300 and into the passage 1004a by the fluid passages 356fa, 356fb, 352a, 348a, 346a, 344a, and 314a. In this manner, surge pressures that can be created during placement of the assembly 300 within the wellbore 1000 are minimized. In a preferred embodiment, the float valve element 354 is pre-set in an auto-fill configuration to permit the fluidic materials 1006 to pass through the conical passage 352a of the valve seat 352.

Referring to Figs. 21a-21c, in step 454, in step 454, fluidic materials 1008 may then be injected into and through the tubular member 1004 and assembly 300 to thereby ensure that all of the fluid passages 1004a, 314a, 344a, 346a, 348a, 352a, 356fa, and 356fb are functioning properly.

Referring to Figs. 22a-22c, in step 456, the bottom plug 1010 may then be injected into the fluidic materials 1008 and into the assembly 300 and then positioned in the throat passage 346aa of the valve member 346. In this manner, the region of the passage 346a upstream from the plug 1010 may be fluidically isolated from the region of the passage 346a downstream from the plug 1010. In a preferred embodiment, the proper placement of the plug 1010 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1008.

Referring to Figs. 29a-29c, in step 458, the fluidic material 1014 may then be injected into the assembly 300 to thereby increase the operating pressure within the passages 314a and 344a until the burst disc 336 is opened thereby permitting the pressurized fluidic material 1014 to pass through the radial passage 330a and into an annular region 1018 defined by the defined by the second tubular support member 314, the third tubular support member 316, the sixth tubular support member 338, the collet



340, the sliding sleeve 342, the valve members, 344 and 348, the shoe 358, and the seventh tubular support member 360. The pressurized fluidic material 1014 within the annular region 1018 directly applies a longitudinal force upon the fifth tubular support member 326 and the sixth tubular support member 338. The longitudinal force in turn  
5 is applied to the expansion cone 318. In this manner, the expansion cone 318 is displaced relative to the expansion cone launcher 320 thereby disengaging the collet 340 and the sliding sleeve 342 and radially expanding and plastically deforming the expansion cone launcher. In a preferred embodiment, the radial expansion process in step 458 is continued to a location below the overlap between the expansion cone  
10 launcher 320 and the preexisting wellbore casing 1002.

Referring to Figs. 30a-30c, in step 460, the sliding sleeve 342 may then be displaced relative to the valve member 344 by (1) displacing the expansion cone 318 in a downward direction using the tubular member 1004 and (2) applying, using the tubular member 1004 a downward force of, for example, approximately 5,000 lbf on  
15 the assembly 300. In this manner, the coupling 340b of the collet 340 reengages the external groove 342e of the sliding sleeve 342. Furthermore, in this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support  
20 member 326, the sixth tubular support member 338, the collet 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the bottom plug 1010 may bypass the plug by passing through the passages, 344da and 344db, the annular passage 342a, the passages, 344fa  
25 and 344fb, the annular passage 350, and the passages, 346ca and 346cb, into the passage 348a downstream from the plug. Furthermore, in this manner, the fluid passage 330a is fluidically isolated from the passages 314a and 344a.

Referring to Figs. 31a-31c, in step 462, the hardenable fluidic sealing material 1012 may then be injected into the assembly 300 and conveyed through the passages  
30 1004a, 314a, 344a, 344da, 344db, 342, 344fa, 344fb, 350, 346ca, 346cb, 348a, 352b, 356fa, and 356fb into the wellbore 1000. In this manner, a hardenable fluidic sealing material such as, for example, cement, may be injected into the annular region between the expansion cone launcher 320 and the wellbore 1000 in order to subsequently form

an annular body of cement around the radially expanded expansion cone launcher 320. Furthermore, in this manner, the radial passage 330a and the rupture disc 336 are not exposed to the hardenable fluidic sealing material 1012.

Referring to Figs. 32a-32c, in step 464, upon the completion of the injection of  
5 the hardenable fluidic sealing material 1012, the nonhardenable fluidic material 1014 may be injected into the assembly 300, and the top plug 1016 may then be injected into the assembly 300 along with the fluidic materials 1014 and then positioned in the throat passage 344aa of the valve member 344. In this manner, the region of the passage 344a upstream from the top plug 1016 may be fluidically isolated from the  
10 region within the passage downstream from the top plug. In a preferred embodiment, the proper placement of the plug 1016 may be indicated by a corresponding increase in the operating pressure of the fluidic material 1014.

Referring to Figs. 33a-33c, in step 466, the sliding sleeve 342 may then be displaced relative to the valve member 344 by displacing the tubular member 1004 by  
15 applying, for example, an upward force of approximately 13,000 lbf on the assembly 300. In this manner, the tubular member 1004, the first tubular support member 312, the second tubular support member 314, the third tubular support member 316, the expansion cone 318, the annular spacer 322, the fourth tubular support member 324, the fifth tubular support member 326, the sixth tubular support member 338, the collet  
20 340, and the sliding sleeve 342 are displaced in the longitudinal direction relative to the expansion cone launcher 320 and the valve member 344. In this manner, fluidic materials within the passage 344a upstream of the bottom plug 110 may no longer bypass the plug by passing through the passages, 344da and 344db, the annular passage 342a, the passages, 344fa and 344fb, the annular passage 350, and the  
25 passages, 346ca and 346cb, into the passage 348a downstream from the plug. Furthermore, in this manner, the passage 330a is no longer fluidically isolated from the fluid passages 314a and 344a.

Referring to Figs. 34a-34c, in step 468, the fluidic material 1014 may be injected into the assembly 300. The continued injection of the fluidic material 1014  
30 may increase the operating pressure within the passages 314a, 330a, and 344a and the annular region 1018. The pressurized fluidic material 1014 within the annular region 1018 directly applies a longitudinal force upon the fifth tubular support member 326 and the sixth tubular support member 338. The longitudinal force in turn is applied to

the expansion cone 318. In this manner, the expansion cone 318 is displaced relative to the expansion cone launcher 320 thereby completing the radial expansion of the expansion cone launcher.

5 In an alternative embodiment of the method 450, the injection and placement of the top plug 1016 into the liner hanger assembly 300 in step 464 may be omitted.

In an alternative embodiment of the method 450, in step 452, the assembly 300 is positioned at the bottom of the wellbore 1000.

10 In an alternative embodiment of the method 450: (1) in step 452, the assembly 300 is positioned proximate a position below a preexisting section of the wellbore casing 1002, and (2) in step 458, the expansion cone launcher 320, and any expandable tubulars coupled to the threaded portion 320c of the expansion cone launcher, are radially expanded and plastically deformed until the shoe 358 of the assembly 300 is proximate the bottom of the wellbore 1000. In this manner, the radial expansion process using the assembly 300 provides a telescoping of the radially expanded  
15 tubulars into the wellbore 1000.

In several alternative embodiments, the assembly 300 may be operated to form a wellbore casing by including or excluding the float valve 354.

20 In several alternative embodiments, the float valve 354 may be operated in an auto-fill configuration in which tabs are positioned between the float valve 354 and the valve seat 352. In this manner, fluidic materials within the wellbore 1000 may flow into the assembly 300 from below thereby decreasing surge pressures during placement of the assembly 300 within the wellbore 1000. Furthermore, pumping fluidic materials through the assembly 300 at rate of about 6 to 8 bbl/min will displace the tabs from the valve seat 352 and thereby allow the float valve 354 to close.

25 In several alternative embodiments, prior to the placement of any of the plugs, 1010 and 1016, into the assembly 300, fluidic materials can be circulated through the assembly 300 and into the wellbore 1000.

30 In several alternative embodiments, once the bottom plug 1010 has been positioned into the assembly 300, fluidic materials can only be circulated through the assembly 300 and into the wellbore 1000 if the sliding sleeve 342 is in the down position.

In several alternative embodiments, once the sliding sleeve 342 is positioned in the down position, the passage 330a and rupture disc 336 are fluidically isolated from pressurized fluids within the assembly 300.

5 In several alternative embodiments, once the top plug 1016 has been positioned into the assembly 300, no fluidic materials can be circulated through the assembly 300 and into the wellbore 1000.

In several alternative embodiments, the assembly 300 may be operated to form or repair a wellbore casing, a pipeline, or a structural support.

10 In a preferred embodiment, the design and operation of the liner hanger assemblies 10 and 300 are provided substantially as described and illustrated in Appendix A to the present application.

In a preferred embodiment, the design and operation of the liner hanger assemblies 10 and 300 are provided substantially as described in one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, 20 filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, 25 (10) U.S. patent application serial no. \_\_\_\_\_, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 30 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. \_\_\_\_\_,

attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. \_\_\_\_\_, attorney docket no. 25791.45, filed on 7/28/2000, and (19) U.S. provisional patent application serial no. \_\_\_\_\_, attorney docket no. 25791.46, filed on 7/28/2000, the disclosures of which are incorporated herein by reference.

A method of forming a wellbore casing within a borehole within a subterranean formation has been described that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the method further includes fluidically isolating the second region from a third region within the expandable tubular member.

An apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the borehole includes means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the apparatus further includes means for fluidically isolating the second region from a third region within the expandable tubular member.

A method of forming a wellbore casing within a borehole within a subterranean formation has also been described that includes positioning an expandable tubular member within the borehole, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, positioning the expandable tubular member within the borehole includes positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole. In an exemplary embodiment, injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole. In an exemplary embodiment, the method further includes fluidically isolating the second region from a third region within the expandable tubular member.

An apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described that includes means for positioning an expandable tubular member within the borehole, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary

embodiment, the means for positioning the expandable tubular member within the borehole includes means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the means for positioning the expandable tubular member within the borehole includes means for  
5 positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole. In an exemplary embodiment, the means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand  
10 at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole. In an exemplary embodiment, the apparatus further includes means for fluidically isolating the second region from a third region within the expandable tubular member.

An apparatus for forming a wellbore casing within a borehole within a  
15 subterranean formation has also been described that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member  
20 defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an  
25 annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

30 An apparatus for forming a wellbore casing in a borehole in a subterranean formation has also been described that includes means for radially expanding an expandable tubular member, and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole. In

an exemplary embodiment, the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole includes a sliding sleeve valve.

A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.



A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the borehole, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the borehole includes positioning an end of the expandable tubular member adjacent to the bottom of the borehole. In an exemplary embodiment, positioning the apparatus within the borehole includes positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole. In an exemplary embodiment, injecting a non-hardenable fluidic

material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member includes injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

A method of coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes positioning an expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the method further includes fluidically isolating the second region from a third region within the expandable tubular member.

An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes means for positioning the expandable tubular member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the preexisting structure includes means for positioning an end of the expandable tubular member

adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the apparatus further includes means for fluidically isolating the second region from a third region within the expandable tubular member.

5 A method of coupling an expandable tubular member to a preexisting structure has also been described that includes positioning the expandable tubular member within the preexisting structure, injecting fluidic materials into the expandable tubular member, fluidically isolating a first region from a second region within the expandable tubular member, injecting a non-hardenable fluidic material into the expandable  
10 tubular member to radially expand at least a portion of the tubular member, fluidically coupling the first and second regions, injecting a hardenable fluidic sealing material into the expandable tubular member, fluidically decoupling the first and second regions, and injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary embodiment, positioning the expandable tubular member within the preexisting structure includes  
15 positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, positioning the expandable tubular member within the preexisting structure includes positioning an end of the expandable tubular member adjacent to a preexisting section of a structural element within the preexisting structure. In an exemplary embodiment, injecting a non-  
20 hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure. In an exemplary embodiment, the method further  
25 includes fluidically isolating the second region from a third region within the expandable tubular member.

An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes means for positioning the expandable tubular  
30 member within the preexisting structure, means for injecting fluidic materials into the expandable tubular member, means for fluidically isolating a first region from a second region within the expandable tubular member, means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a

portion of the tubular member, means for fluidically coupling the first and second regions, means for injecting a hardenable fluidic sealing material into the expandable tubular member, means for fluidically decoupling the first and second regions, and means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member. In an exemplary embodiment, the means for positioning the expandable tubular member within the preexisting structure includes means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the means for positioning the expandable tubular member within the preexisting structure includes means for positioning an end of the expandable tubular member adjacent to a preexisting structural element within the preexisting structure. In an exemplary embodiment, the means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member includes means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure. In an exemplary embodiment, the apparatus further includes means for fluidically isolating the second region from a third region within the expandable tubular member.

20           An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular

region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

5 An apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described that includes means for radially expanding an expandable tubular member, and means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole. In an exemplary embodiment, the means for injecting a hardenable fluidic sealing material into an  
10 annulus between the expandable tubular member and the borehole includes a sliding sleeve valve.

A method of operating an apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described in which the apparatus includes a first  
15 annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an  
20 annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and  
25 movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials  
30 into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing

the annular sleeve to fluidically decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

A method of operating an apparatus for coupling an expandable tubular member to a preexisting structure such as, for example, a wellbore casing, a pipeline, or a structural support has also been described in which the apparatus includes a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage, an annular expansion cone coupled to the first annular support member, an expandable tubular member movably coupled to the expansion cone, a second annular support member defining a second fluid passage coupled to the expandable tubular member, an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member, and an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages. An annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve. The method includes positioning the apparatus within the preexisting structure, injecting fluidic materials into the first, second and third fluid passages, positioning a bottom plug in the bottom throat passage, injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member, displacing the annular sleeve to fluidically couple the second and third radial passages, injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages, displacing the annular sleeve to fluidically

decouple the second and third radial passages, and injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member. In an exemplary embodiment, positioning the apparatus within the preexisting structure includes positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure. In an exemplary embodiment, positioning the apparatus within the preexisting structure includes positioning an end of the expandable tubular member adjacent to a preexisting section of a structural element casing within the preexisting structure. In an exemplary embodiment, injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member includes injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure. In an exemplary embodiment, the method further includes positioning a top plug in the top throat passage.

Although this detailed description has shown and described illustrative embodiments of the invention, this description contemplates a wide range of modifications, changes, and substitutions. In some instances, one may employ some features of the present invention without a corresponding use of the other features. Accordingly, it is appropriate that readers should construe the appended claims broadly, and in a manner consistent with the scope of the invention.

## Claims

1. An apparatus for forming a wellbore casing in a borehole in a subterranean formation, comprising:
  - means for radially expanding an expandable tubular member; and
  - 5 means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.
2. The apparatus of claim 1, wherein the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the  
10 borehole, comprises:
  - a sliding sleeve valve.
3. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:
  - 15 means for radially expanding and plastically deforming the expandable tubular member within the preexisting strcuture; and
  - means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the preexisting structure.
- 20 4. The apparatus of claim 3, wherein the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the preexisting structure, comprises:
  - a sliding sleeve valve.



What is claimed is:

1. A method of forming a wellbore casing within a borehole within a subterranean formation, comprising:
  - positioning an expandable tubular member within the borehole;
  - 5 injecting fluidic materials into the expandable tubular member;
  - fluidicly isolating a first region from a second region within the expandable tubular member;
  - fluidicly coupling the first and second regions;
  - injecting a hardenable fluidic sealing material into the expandable tubular
  - 10 member;
  - fluidicly decoupling the first and second regions; and
  - injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.
- 15 2. The method of claim 1, wherein positioning the expandable tubular member within the borehole comprises:
  - positioning an end of the expandable tubular member adjacent to the bottom of the borehole.
- 20 3. The method of claim 1, further comprising:
  - fluidicly isolating the second region from a third region within the expandable tubular member.
4. An apparatus for forming a wellbore casing within a borehole within a
- 25 subterranean formation, comprising:
  - means for positioning an expandable tubular member within the borehole;
  - means for injecting fluidic materials into the expandable tubular member;
  - means for fluidicly isolating a first region from a second region within the expandable tubular member;
  - 30 means for fluidicly coupling the first and second regions;
  - means for injecting a hardenable fluidic sealing material into the expandable tubular member;
  - means for fluidicly decoupling the first and second regions; and

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

5. The apparatus of claim 4, wherein the means for positioning the expandable tubular member within the borehole comprises:  
5 means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

6. The apparatus of claim 4, further comprising:  
10 means for fluidically isolating the second region from a third region within the expandable tubular member.

7. A method of forming a wellbore casing within a borehole within a subterranean formation, comprising:  
15 positioning an expandable tubular member within the borehole;  
injecting fluidic materials into the expandable tubular member;  
fluidically isolating a first region from a second region within the expandable tubular member;  
injecting a non-hardenable fluidic material into the expandable tubular member  
20 to radially expand at least a portion of the tubular member;  
fluidically coupling the first and second regions;  
injecting a hardenable fluidic sealing material into the expandable tubular member;  
fluidically decoupling the first and second regions; and  
25 injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

8. The method of claim 7, wherein positioning the expandable tubular member within the borehole comprises:  
30 positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

9. The method of claim 7, wherein positioning the expandable tubular member within the borehole comprises:

positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole.

5

10. The method of claim 7, wherein injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:

injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole.

10

11. The method of claim 7, further comprising:

fluidically isolating the second region from a third region within the expandable tubular member.

15

12. An apparatus for forming a wellbore casing within a borehole within a subterranean formation, comprising:

means for positioning an expandable tubular member within the borehole;  
means for injecting fluidic materials into the expandable tubular member;  
means for fluidically isolating a first region from a second region within the expandable tubular member;  
means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;  
means for fluidically coupling the first and second regions;  
means for injecting a hardenable fluidic sealing material into the expandable tubular member;  
means for fluidically decoupling the first and second regions; and  
means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.

20

25

30

13. The apparatus of claim 12, wherein means for positioning the expandable tubular member within the borehole comprises:  
5 means for positioning an end of the expandable tubular member adjacent to the bottom of the borehole.
14. The apparatus of claim 12, wherein means for positioning the expandable tubular member within the borehole comprises:  
10 means for positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole.
15. The apparatus of claim 12, wherein means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:  
15 means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole.
- 20 16. The apparatus of claim 12, further comprising:  
means for fluidically isolating the second region from a third region within the expandable tubular member.
- 25 17. An apparatus for forming a wellbore casing within a borehole within a subterranean formation, comprising:  
a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage;  
an annular expansion cone coupled to the first annular support member;  
30 an expandable tubular member movably coupled to the expansion cone;  
a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and  
5 movably coupled to the first annular support member; and  
an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages; and  
wherein an annular region is defined by the region between the tubular member  
10 and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve.

18. An apparatus for forming a wellbore casing in a borehole in a subterranean formation, comprising:

15 means for radially expanding an expandable tubular member; and  
means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole.

19. The apparatus of claim 18, wherein the means for injecting a hardenable fluidic sealing material into an annulus between the expandable tubular member and the borehole, comprises:  
20 a sliding sleeve valve.

20. A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation, the apparatus comprising:  
25 a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage;  
an annular expansion cone coupled to the first annular support member;  
30 an expandable tubular member movably coupled to the expansion cone;  
a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and  
5 movably coupled to the first annular support member; and  
an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages; and  
wherein an annular region is defined by the region between the tubular member  
10 and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;  
the method comprising:  
positioning the apparatus within the borehole;  
injecting fluidic materials into the first, second and third fluid passages;  
15 positioning a bottom plug in the bottom throat passage;  
displacing the annular sleeve to fluidically couple the second and third radial passages;  
injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;  
20 displacing the annular sleeve to fluidically decouple the second and third radial passages; and  
injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand the expandable tubular  
25 member.

21. The method of claim 20, wherein positioning the apparatus within the borehole comprises:  
30 positioning an end of the expandable tubular member adjacent to the bottom of the borehole.
22. The method of claim 20, further comprising:  
positioning a top plug in the top throat passage.

23. A method of operating an apparatus for forming a wellbore casing within a borehole within a subterranean formation, the apparatus comprising:

a first annular support member defining a first fluid passage and one or more  
5 first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to  
10 the expandable tubular member;

an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages, defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and  
15 movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member  
20 and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;

the method comprising:

positioning the apparatus within the borehole;

injecting fluidic materials into the first, second and third fluid passages;

25 positioning a bottom plug in the bottom throat passage;

injecting a non-hardenable fluidic material through the first fluid passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member;

30 displacing the annular sleeve to fluidically couple the second and third radial passages;

injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;

displacing the annular sleeve to fluidically decouple the second and third radial passages; and  
injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves  
5 into the annular region to radially expand another portion of the expandable tubular member.

24. The method of claim 23, wherein positioning the apparatus within the borehole comprises:  
10 positioning an end of the expandable tubular member adjacent to the bottom of the borehole.

25. The method of claim 23, wherein positioning the apparatus within the borehole comprises:  
15 positioning an end of the expandable tubular member adjacent to a preexisting section of wellbore casing within the borehole.

26. The method of claim 23, wherein injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to  
20 radially expand a portion of the expandable tubular member comprises:  
injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the borehole.

25  
27. The method of claim 23, further comprising:  
positioning a top plug in the top throat passage.

28. A method of coupling an expandable tubular member to a preexisting structure,  
30 comprising:  
positioning the expandable tubular member within the preexisting structure;  
injecting fluidic materials into the expandable tubular member;



- fluidically isolating a first region from a second region within the expandable tubular member;  
fluidically coupling the first and second regions;  
injecting a hardenable fluidic sealing material into the expandable tubular member;  
5 fluidically decoupling the first and second regions; and  
injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.
- 10 29. The method of claim 28, wherein positioning the expandable tubular member within the preexisting structure comprises:  
positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.
- 15 30. The method of claim 28, further comprising:  
fluidically isolating the second region from a third region within the expandable tubular member.
- 20 31. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:  
means for positioning the expandable tubular member within the preexisting structure;  
means for injecting fluidic materials into the expandable tubular member;  
means for fluidically isolating a first region from a second region within the expandable tubular member;  
25 means for fluidically coupling the first and second regions;  
means for injecting a hardenable fluidic sealing material into the expandable tubular member;  
means for fluidically decoupling the first and second regions; and  
30 means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand the tubular member.

32. The apparatus of claim 31, wherein the means for positioning the expandable tubular member within the preexisting structure comprises:  
means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.
- 5 33. The apparatus of claim 31, further comprising:  
means for fluidically isolating the second region from a third region within the expandable tubular member.
- 10 34. A method of coupling an expandable tubular member to a preexisting structure, comprising:  
positioning the expandable tubular member within the preexisting structure;  
injecting fluidic materials into the expandable tubular member;  
fluidically isolating a first region from a second region within the expandable  
15 tubular member;  
injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;  
fluidically coupling the first and second regions;  
injecting a hardenable fluidic sealing material into the expandable tubular  
20 member;  
fluidically decoupling the first and second regions; and  
injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular member.
- 25 35. The method of claim 34, wherein positioning the expandable tubular member within the preexisting structure comprises:  
positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.
- 30 36. The method of claim 34, wherein positioning the expandable tubular member within the preexisting structure comprises:  
positioning an end of the expandable tubular member adjacent to a preexisting tubular structural element within the preexisting structure.

37. The method of claim 34, wherein injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:

5       injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure.

10   38. The method of claim 34, further comprising:  
      fluidically isolating the second region from a third region within the expandable tubular member.

39. An apparatus for coupling an expandable tubular member to a preexisting  
15   structure, comprising:  
      means for positioning the expandable tubular member within the preexisting structure;  
      means for injecting fluidic materials into the expandable tubular member;  
      means for fluidically isolating a first region from a second region within the  
20       expandable tubular member;  
      means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member;  
      means for fluidically coupling the first and second regions;  
25       means for injecting a hardenable fluidic sealing material into the expandable tubular member;  
      means for fluidically decoupling the first and second regions; and  
      means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand another portion of the tubular  
30       member.

40. The apparatus of claim 39, wherein means for positioning the expandable tubular member within the preexisting structure comprises:

means for positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

41. The apparatus of claim 39, wherein means for positioning the expandable tubular member within the preexisting structure comprises:

means for positioning an end of the expandable tubular member adjacent to a preexisting structural element within the preexisting structure.

42. The apparatus of claim 39, wherein means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member comprises:

means for injecting a non-hardenable fluidic material into the expandable tubular member to radially expand at least a portion of the tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure.

43. The apparatus of claim 39, further comprising:

means for fluidically isolating the second region from a third region within the expandable tubular member.

44. An apparatus for coupling an expandable tubular member to a preexisting structure, comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having first and second throat passages, defining second and third radial passages fluidically coupled to the third

fluid passage, coupled to the second annular support member, and  
movably coupled to the first annular support member; and  
an annular sleeve releasably coupled to the first annular support member and  
movably coupled to the annular valve member for controllably fluidically  
coupling the second and third radial passages; and  
wherein an annular region is defined by the region between the tubular member  
and the first annular support member, the second annular support  
member, the annular valve member, and the annular sleeve.

45. An apparatus for coupling an expandable tubular member to a preexisting  
structure, comprising:

means for radially expanding an expandable tubular member; and  
means for injecting a hardenable fluidic sealing material into an annulus  
between the expandable tubular member and the borehole.

46. The apparatus of claim 45, wherein the means for injecting a hardenable fluidic  
sealing material into an annulus between the expandable tubular member and the  
borehole, comprises:  
a sliding sleeve valve.

47. A method of operating an apparatus for coupling an expandable tubular  
member to a preexisting structure, the apparatus comprising:  
a first annular support member defining a first fluid passage and one or more  
first radial passages having pressure sensitive valves fluidically coupled to  
the first fluid passage;  
an annular expansion cone coupled to the first annular support member;  
an expandable tubular member movably coupled to the expansion cone;  
a second annular support member defining a second fluid passage coupled to  
the expandable tubular member;  
an annular valve member defining a third fluid passage fluidically coupled to the  
first and second fluid passages having top and bottom throat passages,  
defining second and third radial passages fluidically coupled to the third

fluid passage, coupled to the second annular support member, and  
movably coupled to the first annular support member; and  
an annular sleeve releasably coupled to the first annular support member and  
movably coupled to the annular valve member for controllably fluidically  
coupling the second and third radial passages; and  
wherein an annular region is defined by the region between the tubular member  
and the first annular support member, the second annular support  
member, the annular valve member, and the annular sleeve;

the method comprising:

- 10 positioning the apparatus within the preexisting structure;  
injecting fluidic materials into the first, second and third fluid passages;  
positioning a bottom plug in the bottom throat passage;  
displacing the annular sleeve to fluidically couple the second and third  
radial passages;
- 15 injecting a hardenable fluidic sealing material through the first, second,  
and third fluid passages, and the second and third radial passages;  
displacing the annular sleeve to fluidically decouple the second and third  
radial passages; and
- 20 injecting a non-hardenable fluidic material through the first fluid  
passage and the first radial passages and pressure sensitive valves  
into the annular region to radially expand the expandable tubular  
member.

48. The method of claim 47, wherein positioning the apparatus within the  
25 preexisting structure comprises:  
positioning an end of the expandable tubular member adjacent to the bottom of  
the preexisting structure.

49. The method of claim 47, further comprising:  
30 positioning a top plug in the top throat passage.

50. A method of operating an apparatus for coupling an expandable tubular  
member to a preexisting structure, the apparatus comprising:

a first annular support member defining a first fluid passage and one or more first radial passages having pressure sensitive valves fluidically coupled to the first fluid passage;

an annular expansion cone coupled to the first annular support member;

5 an expandable tubular member movably coupled to the expansion cone;

a second annular support member defining a second fluid passage coupled to the expandable tubular member;

an annular valve member defining a third fluid passage fluidically coupled to the first and second fluid passages having top and bottom throat passages,  
10 defining second and third radial passages fluidically coupled to the third fluid passage, coupled to the second annular support member, and movably coupled to the first annular support member; and

an annular sleeve releasably coupled to the first annular support member and movably coupled to the annular valve member for controllably fluidically  
15 coupling the second and third radial passages; and

wherein an annular region is defined by the region between the tubular member and the first annular support member, the second annular support member, the annular valve member, and the annular sleeve;

the method comprising:

20 positioning the apparatus within the preexisting structure;  
injecting fluidic materials into the first, second and third fluid passages;  
positioning a bottom plug in the bottom throat passage;  
injecting a non-hardenable fluidic material through the first fluid

25 passages and the first radial passages and pressure sensitive valves into the annular region to radially expand a portion of the expandable tubular member;

displacing the annular sleeve to fluidically couple the second and third radial passages;

30 injecting a hardenable fluidic sealing material through the first, second, and third fluid passages, and the second and third radial passages;  
displacing the annular sleeve to fluidically decouple the second and third radial passages; and

injecting a non-hardenable fluidic material through the first fluid passage and the first radial passages and pressure sensitive valves into the annular region to radially expand another portion of the expandable tubular member.

5

51. The method of claim 50, wherein positioning the apparatus within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to the bottom of the preexisting structure.

10

52. The method of claim 50, wherein positioning the apparatus within the preexisting structure comprises:

positioning an end of the expandable tubular member adjacent to a preexisting section of a structural element within the preexisting structure.

15

53. The method of claim 50, wherein injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand a portion of the expandable tubular member comprises:

injecting a non-hardenable fluidic material into the first fluid passage and first radial passages and pressure sensitive valves to radially expand the expandable tubular member until an end portion of the tubular member is positioned proximate the bottom of the preexisting structure.

20

54. The method of claim 50, further comprising:

positioning a top plug in the top throat passage.

25





INVESTOR IN PEOPLE

Application No: GB0411894.9

Examiner: David Pepper

Claims searched: 1-4

Date of search: 29 June 2004

## Patents Act 1977: Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular reference
X	1,3	US 6085838 A (Vercaemer et al) - see figs 5-7 and col 7, lines 6-22 and 52-57

### Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>W</sup> :

Worldwide search of patent documents classified in the following areas of the IPC<sup>07</sup>

The following online and other databases have been used in the preparation of this search report

U.S. : 166/277,382,177.4,206,207,242.2